NOTES ON AUSTRALIAN QUATERNARY CLIMATES AND MIGRATION

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Plate 2, Figs. 1-13.

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These notes were made, in the first instance, on climates suggested by the texture and fossils of some Victorian deposits that contained artefacts. But to understand the diversity of climates, it was found necessary to investigate the effects of the Postglacial and Pleistocene interglacial and glacial stages in the Southern Hemisphere and this led to their further elaboration. Apart from regulating the march of the climatic belts and its effect on habitability, it became evident that the interglacial and glacial stages were responsible for oscillations in sea-level that modified the geographical distribution of land and sea, particularly in northern Australia. Obviously, these oscillations had a profound bearing on immigration to Australia, but in a somewhat different way to that suggested elsewhere; the changing climate has also influenced migration in Australia.

Marett (1938) succinctly suggests the scope of this enquiry:

> The anthropo-geographer can afford to concentrate on climate, treating fauna and flora, and even avenues of migration, as dependent subjects. Calculating temperature, rainfall and so on for given regions as the climate varies, he can proceed to map out areas of relative habitability, suiting man more or less closely, according to his degree of culture . . . Thus the study of environment teaches the anthropologist where to look alike for the strong and for the weak among the human candidates for survival. Geographical considerations will not suffice to explain the full conditions of the struggle between ethnic types but whoever aspires to understand human history as a whole must at least acquire the map-making, map-reading faculty at the start.

In Australia, the pioneer of this class of research was Griffith Taylor (1919) who showed how changes in temperature affected the rain-belts now and under somewhat hotter (Pliocene) and colder (Quaternary) conditions. The basic principles underlying such an investigation he (Taylor, 1927) stated in the following words:

> If the land be subjected to cooler temperatures, this is equivalent to increasing the factors which bring the southern rain belt to Australia. We should expect a strengthening of this rain belt so that it should become broader; in effect, the desert would retreat to the north. If the climate as a whole became hotter we should expect a movement south of the desert and a deterioration in the living conditions of southern Australia.

He illustrates this by maps (Taylor, 1919, 1927).

In the several maps given here, the line of advance and retreat of the climatic belts is taken to be the axis of the overlap of the tropical low pressure rainfall and the southern low pressure rainfall; this is referred to here as the "line of maximum aridity." (Fig. 1).

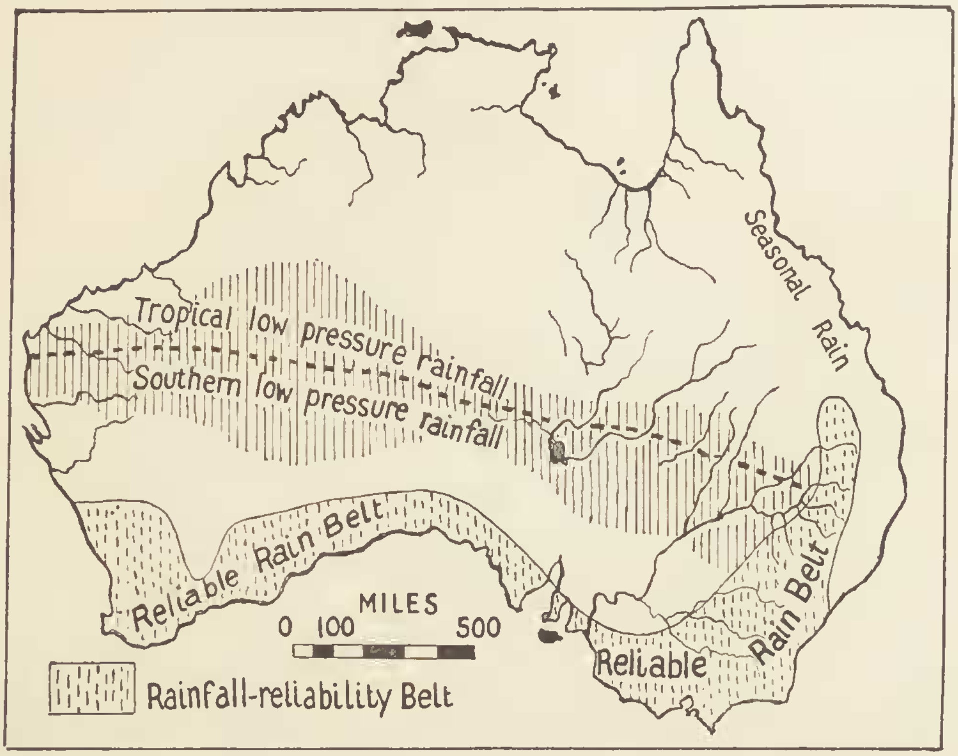

Fig. 1.
Present Line of Maximum Aridity and the Range of the Rainfall-reliability Belt.

This paper discusses:

I. The march of the climatic belts.
II. Rainfall: fertility and aridity.
III. Deposits containing artefacts.
 a. Tartanga and Devon Downs.
 b. Dunes at Altona and Point Cook.
 c. Deposits under lava-flows and volcanic ejectamenta.
IV. Bones shaped by man or animals.
V. Palaeogeography of the Postglacial and last glacial periods.
VI. Probable landing places.

VII. Critical millennia.
VIII. Migration routes in Australia.
IX. Digest of conclusions.

As far as possible, the writer has restricted his comments to the geology of deposits in south-east Australia containing artefacts, the climates implied by such deposits, and the palaeogeography at critical periods. Where references are made to social anthropology, their sources are given.

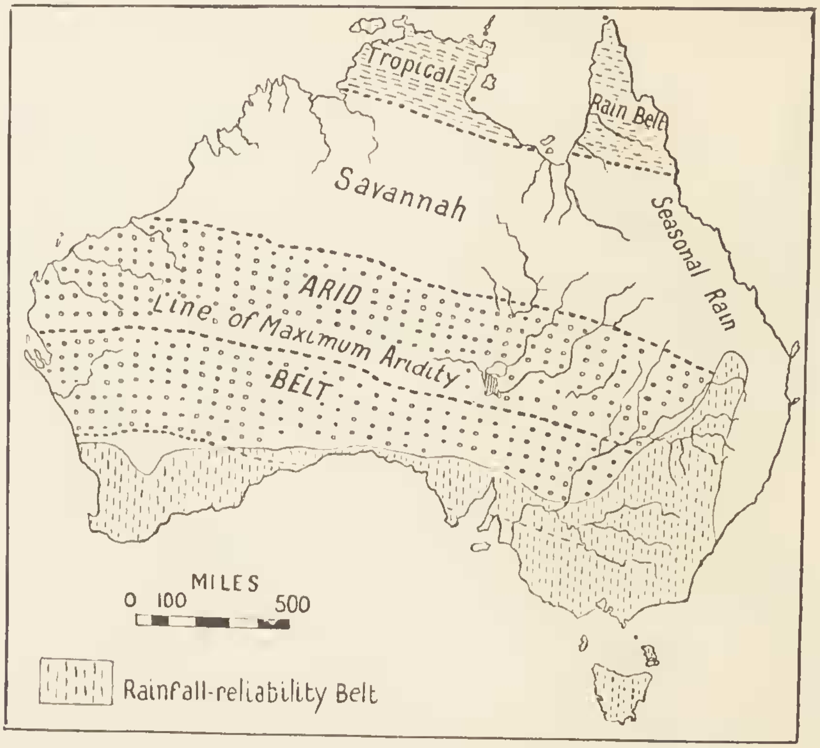

FIG. 2.
Climatic Belts and Rainfall-reliability Belt at the Postglacial Optimum.

(1). March of the Climatic Belts.

In Australia during the Quaternary period, the climatic belts moved northwards in the glacial periods and southwards in the Postglacial and interglacial periods; with them moved the forest, savannah, arid and steppe belts. A variation in temperature of 12° F. is involved, equivalent to a movement north or south of 800 miles. With the advance of the belts, a region may have passed successively from desert into savannah to tropical rainforest; from aridity into relative fertility to revert on their retreat to its former state. Thus the line of maximum aridity during the glacial period was approximately 200 miles south of Darwin, but at the Postglacial Optimum 400 miles north of Adelaide. (Fig. 2).

During the glacial period, only the higher altitudes of Australia were beset with glacial conditions—the Margaret glaciation—which were too restricted to affect to any extent the climate: any reference here to glacial or interglacial in connection with the mainland refers only to the periods when those stages prevailed in other latitudes. The following were the climatic, and hence the physical extremes, in the Australian region during the Quaternary:

	Postglacial and interglacial Periods.	Glacial Period.
New Guinea.	Tropical rain-forest.	Savannah.
Northern Australia.	Savannah and tropical rain-forest.	Arid belt.
Lake Eyre Basin.	Arid belt.	Steppe.
South-east Australia.	Steppe.	Temperate rain-forest.
Tasmania.	Temperate.	Glaciated.

The south-east, the coastal corridor, the orographic rainfall-belt and the extreme south-west of Australia have always been regions that have been more or less fertile; the rest of it has been at some time successively desert or on the borderline of complete aridity, savannah, steppe, or partly in the fertile belt. In Europe, the continental character of the climate during the retreat of the ice-sheet that ushered in the dry period, although largely influenced by geographical distribution, was, to some extent, due to astronomical causes, and assuredly had its equivalent in the Southern Hemisphere. It concluded about 4,000 B.C., when there was a period of submergence—the Atlantic stage. The Postglacial Optimum is placed here about 2,000 B.C.—i.e., 4,000 years ago (cf. Brooks, 1922). A progressive change of climate leading to the Postglacial Optimum has been assumed, although, doubtless, there have been minor climatic fluctuations; the small amount of geographical change that has occurred in Australia in the Postglacial—it has occurred mainly in the north—has probably made these less marked and infrequent. Glaciation ended in lowland Europe about 7,000 years ago, but the climate became appreciably warmer about 8,000 years ago.

Glaciation on the Australian mainland was restricted during the last glacial period to a small area on Mt. Kosciusko. In Tasmania there were at least three glaciations, in local terminology, the Margaret, Yolandean, and Malannan stages, most fully described by Lewis (1945). These are respectively probably the equivalents of the Wurm, Riss, and Mindel glacial stages of the Northern Hemisphere. The Margaret glaciation occurred after the formation of Bass Strait, the Yolandean and Malannan before. Two glaciations have occurred at Mt. Kosciusko (7328 ft.) on the Kosciusko plateau, the newer of which David (1923) has correlated with the Wurm (Margaret), and the older with the Mindel (Malannan). In regard to the more recent changes in climate, we are concerned with those after the Margaret glaciation; this David divided into the Post-Wurm Mountain Glaciation and the Wurm Glaciation, but seemingly, these may be regarded as phases of the Margaret. In respect to the summit of Mt. Kosciusko, he states that the Mountain Glaciation extended down to 6,400 feet and the Wurm down to 6,150 feet, 928 and 1,178 feet respectively below the summit.

The paths of the lows have changed with the passing north and south of the glacial, Postglacial, and interglacial periods: the eastern and western littorals have been most affected by the contemporaneous passing backwards and forwards of the rain-belt. Information concerning the present paths of the depressions is far from complete and any deductions from it must necessarily be tentative.

The general direction of the high pressure belt with its complementary lows is, in the Australian region, a little south of east. Due to the existence of a greater land-surface in the Northern Hemisphere, their direction is there less defined. Brooks (1926) states:

> Although the paths of the individual depressions in temperate regions often appear to be erratic, it has been found possible to classify them into a number of tracks, which are more usually followed than the intervening regions. These tracks have a preference for moist areas, especially such inland seas as the English Channel, the Baltic, and the Mediterranean, or for well watered plains such as Hungary and Poland . . . The question of the tracks of depressions is important for palaeometeorology, for a considerable degree of permanence has been attributed to them.

As most of the reliable rainfall along the south coast of Australia is associated with the winter Antarctic low, the average position of its axis is important from the standpoint of this discussion. Taylor (1920) shows that it trends E.S.E. by a straight line from a point about 250 miles south of Cape Leeuwin and that it enters Bass Strait between King Island and Tasmania. This is the path at present, 4,000 years after the Postglacial Optimum; it was also the path 4,000 years before the Postglacial

Optimum, or 8,000 years ago. The probable paths now and in the past are shown in Fig. 3.

The Southern Ocean Current profoundly affects the climate of a large part of Australia, particularly its south-eastern portion. It bifurcates some hundreds of miles south-west of Cape Leeuwin: one branch flows northwards up the west coast, the other eastwards along the south coast impelled by the anti-trade winds. It receives a great indraft of cold water from the Antarctic Ocean, and, west of Cape Leeuwin, a surface indraft of warm water from the Indian Ocean. The *Challenger* Expedition recorded the latter as a warm sub-surface current off Cape Northumberland at the south-east corner of South Australia about 400 miles wide

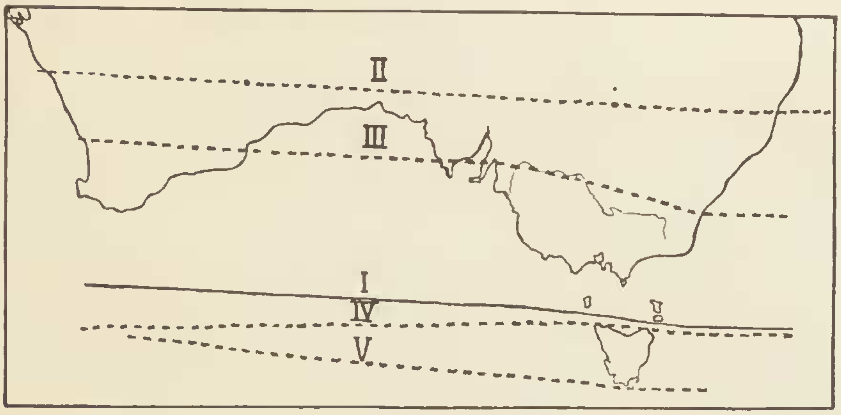

FIG. 3.

Approximate positions of paths of lows at present and in the past. I. During the six cool months (after Taylor, 1920, Fig. 132) and also 8,000 years ago; II. at last glacial maximum; III. 15,000 years ago when the tropical rain-forest reached Australia; IV. at Postglacial Optimum, 4,000 years ago; V. before existence of Bass Strait.

and about 250 fathoms deep flowing easterly. At Cape Leeuwin it is a surface current, but at Cape Northumberland it is about 150 fathoms below the surface and has cooled about 16 degrees.

Halligan (1921) states:

> The southern branch continues as an easterly surface current across the Bight, with a rate varying from ·3 to ·4 knot as far as Spencer Gulf. The warm current from the Indian Ocean, which appears to be confined to the Bight, to that point, here dips below and becomes partly merged in the main stream until it strikes the Tasmanian Plateau. This obstruction, by deflecting the current to the south-east, causes a further mixing of the warm and cold waters, which accounts for the water in Bass Strait being generally from 2° to 4° colder than the water off Cape Northumberland.

He observes that the Tasmanian Plateau also retards the current velocity in Bass Strait to the extent that the tidal currents become more important and that both are largely dominated by the wind. The main body, however, sweeps along the western side of the plateau, turning sharply and with increased velocity to the east round S.W. Cape at the south-west corner of Tasmania. These are the conditions that have existed since the formation of Bass Strait, but before that, the whole volume of the current was diverted south-easterly along the western side of the plateau—the pre-Yolandean shoreline. The south-east corner of the mainland did not experience the climatic influence of that portion that now passes through Bass Strait, which, considering the temperature of the Southern Ocean Current is less than 62° F., must have been appreciable.

II. Rainfall: Fertility and Aridity.

The present rainfall-reliability belt is shown in Fig. 1; it is substantially that shown by Taylor (1920, Fig. 125). It extends from west to east across southern Australia to the Dividing Range, and north, for the most part, along the western slopes of the range into Queensland. The arid belt terminates against its western boundary and the reliable rainfall belt extends some 250 miles north of the line of maximum aridity (Fig. 1). Falling for the most part on the western slopes of the Dividing Range, the reliable rainfall is closely connected with the Antarctic lows travelling from west to east and is obviously mainly orographic.

The rainfall of the coastal corridor between the Dividing Range and the east coast, other than the cyclonic rain, comes mostly with the trade-winds that extend furthermost south in the summer months. The rainfall of the north portion of the corridor is seasonal. The corridor has always had a useful, if uneven, rainfall, particularly that part of it south of the Tropic of Capricorn; the number of permanent coastal streams draining is evidence of this. It connects northern Australia with south-east and southern Australia by a fertile belt—a fact plainly evident in the distribution of the white population.

During the last glacial period, the reliable rainfall extended along the western slopes of the Dividing Range to the Atherton Plateau in North Queensland (Fig. 13); this was the period of the greatest and most extensive fertility for eastern Australia. The rainfall-reliability belt receded slowly southwards until the Postglacial Optimum, but has since been moving northwards.

Such streams as the Diamantina and the Georgina flowing south had their sources in the extension eastwards of the Selwyn Highlands, a low physiographical divide that, owing to its trend, does not intercept orographical rainfall. These intermittent watercourses, together with the south-west flowing Cooper, are outlets to the Lake Eyre Basin at the present time of from 15 to 20 inches of mostly summer tropical rainfall falling on the southern slopes of the Selwyn Highlands and on the western slopes of the Dividing Range. The effects of climatic change and the contraction of the rainfall-belt on these streams will be discussed under the heading Migration Routes (Part VIII).

In the tropical rain-belt, in Australia, there is a rain-forest comparable, as regards its ecology, with that in the Malay Archipelago and the Malay Peninsula; it is restricted to its northern part. The sub-tropical dry belt—the summer rain-region of Australia, savannah and grassland — includes, at present, a large portion of the north, south of the tropical rain-belt. On the poleward sides of the latter, in both Hemispheres, one passes into the arid belts, such as that in Central Australia, with slight or no rainfall. It is difficult to gauge the aridity of this in the past. At present the arid belt crosses Australia to south-west Queensland and north-west New South Wales to the edge of the rainfall-reliability belt; as already noted, it does not cross the latter into the coastal corridor. It includes the Lake Eyre Basin that normally receives less than 5 inches of rainfall, wholly convectional, but for periods of years no rainfall at all. Heat and consequently evaporation are excessive, the former not much less than the hottest parts of the Sahara (Kendrew, 1937), yet scarcely any of its western portion is true desert and is not as arid as some at the waterless west-coast deserts of other continents. Commenting on the desert-phase, Brooks (1926) states:

> In parts of the South American desert it has probably not rained for centuries. Such plants as there are show special devices to prevent the loss of water, but in many deserts the ground is entirely bare of plants. Among animals, one of the most characteristic is the lung-fish (*Ceratodus*), which is adapted to breathe either air or water, and can remain dried up for long periods.

Ceratodus is still living in Australia and is significantly found in what are now well-watered seasonal rainfall-tracts.

The gibber plains of Australia attest long and recurrent periods of aridity in the Quaternary. At the Postglacial Optimum the line of maximum aridity was through Marree, about 50 miles south of Lake Eyre, and the arid belt was then hotter and more arid. This hot period which was world-wide ended about 2,000 years ago and lasted about 4,000 years. Howchin (1913) believed the present arid conditions of Central Australia had a gradual evolution and were due to the sunkland in south Central Australia which had the effect of raising the mean annual temperature. The increased temperature prevented rain falling on the advanced side of a barometric depression and limited it to the departing quadrant. These, he maintained, are the typical conditions of the rainfall of South Australia at the present time. He also attributes aridity to physiographical changes, but the writer has reason to believe that his conclusions are not supported by current research.

In the Lake Eyre Basin, the sub-surface deposits contain the remains of *Diprotodon,* crocodiles, chelonians and other forms implying wetter, moister conditions. The surface deposits accumulated during the warmer period of the Postglacial Optimum and have been transported thither by the spasmodic drainage accompanying convectional and seasonal tropical rainfall; the sub-surface deposits were deposited during the earlier part of the Postglacial or the last glacial period.

The effect of the hot period of the Postglacial Optimum is seen in the forests of eastern Australia. Taylor (1920) observes that many plants require rainfall all through the year, a break of a month or two being deleterious; this applies especially to the tropical forest element present along the east coast and south-east coast of Australia. He found that the 12 isopleth, which bounds on the west, the region receiving at least an inch of rain each month of the twelve, does not coincide with the limits of the thick tropical or temperate forest, so he plotted the line bounding the region where an additional inch fell during each of seven months on the regions of considerable rainfall. This was found to agree closely with the distribution of both the tropical and temperate forest. In this area, the rainfall practically equals evaporation and the required rainfall seems to be largely a matter of elevation; evaporation is a much more potent factor on the lowlands west of the highlands of eastern Australia than on the highlands themselves. During the warm period of the Postglacial Optimum the forests must have been much more restricted than they are today.

Southwards of the arid belt is the Mediterranean type of climate with an increased winter rainfall, but hot, generally rainless summers; this type passes into the temperate rain-belt. South of this is the boreal belt in which a terrestrial region is characterized by an ample coastal rainfall, but usually a dry interior; the winter is severe with a persistent snow cover and the summer is short. Evidence of it in Australia during the glacial period is seen in the peat deposits in southern Victoria and Tasmania; peat formation calls for a rainfall of at least 40 inches and a mean temperature above 40°F.

III. Deposits containing Artefacts.

The first appearance of the Proto-Indics or Australoids in Australia, in its present form, is of some antiquity; they came many thousands of years ago, but the time that has elapsed since their arrival is short compared, for instance, to that which has passed since the Neanderthal appeared in Europe. In reviewing here the stratigraphic positions of artefacts and the climatic changes disclosed by the sections, only the more reliable finds have been selected. One from outside Victoria has been included, Hale and Tindale's classic investigation at Tartanga and Devon Downs; it is felt that their evidence may be accepted without reservations and should be summarized here as many of the problems raised occur in Victoria. The Victorian records are less reliable; like many archæological discoveries nearly all of them were made by unskilled observers, but the evidence is at least as trustworthy as that of some accepted finds.

Little has been attempted in Australia in correlating the Recent or Postglacial and the Pleistocene sediments with climatic change. Archæological research in Australia has not as yet supplied the close subdivision worked out in Europe, nor are there any literary records or traditions to corroborate the more recent events: for these reasons the dating of them must always be an approximation. The bearing of climatic change in the Postglacial and Pleistocene has hitherto only been touched on in a perfunctory way and it is realized that the problems they raise can only be settled by marshalling more evidence; it is hoped, nevertheless, that their discussion may stimulate this. We are very much in the same position in Australia at present as they were in America when comparative records were not available there as to the conditions that prevailed before the coming of the white man. But a record of the climatic changes has been pushed back in America for 3,000 years by a close study of the growth-rings of trees. It has been said that the eucalypts do not lend themselves to dendrochronology like the American trees, but there is evidence of what appear to be largely climatic fluctuations in the former levels of lakes. Many of these lakes have no outlets and would appear to be suited to such an investigation. It is possible that by correlating the evidence they reveal with such as may be obtained from the study of growth-rings, a more or less reliable record might be obtained. One could not expect the comparative accuracy of the Caspian levels which are substantiated by literary and archæological records, but such a record would, nevertheless, be valuable.

A. *Evidence at Tartanga and the Devon Downs Shelter.*

This important investigation was conducted by Hale and Tindale (1930) who excavated the Tartanga deposits and the Devon Downs Shelter on the lower Murray, South Australia. They summarize the evidence of Tartanga, where there are human remains associated with food-debris and old industries, by the statement that the "geological and physiographical features show that these occupational records are at least of some antiquity." Because it throws some light on climate and supplies a standard for comparison, the Devon Downs succession is given here with that at Tartanga.

Devon Downs Shelter.		*Tartanga.*	
I.	Late Murundian. Hammer-stone, chippings, flakes, red-ochre.	I.	Signs of human occupation. A few hand-mills, no definite stone artefacts. A few stone chippings.
II.	Murundian. Human remains, bone implements, stone chippings, red ochre.	H.	Numerous signs of intensive occupation, hearths, ash, etc.
III.	Murundian. Human remains, bone and stone implements of indefinite type.	G.	A single flake, exhibiting what may be poor attempts at secondary chipping.
IV.	Early Murundian. Human remains. Bone and stone implements of definite shape.	F.	A crude millstone.
V.	Mudukian. Bone implements and definite stone implements similar to VI and VII.	E.	Human remains. Bone implements. Stone chippings.
VI.	Mudukian. Human remains. Bone implements including *muduk* or fishing-bone. Stone implements.	D.	Human remains. Implements, millstones, pounding and grinding stones, chippings.
VII.	Mudukian. Bone and stone implements.	C.	Human skeleton. Stone implements and chippings.
VIII.	Pirrian. Typical stone and bone implements including *pirri.*	B.	Burnt stones, stone chippings or flakes. Bone implements.
IX.	Pirrian. Stone and bone implements including *pirri.*	A.	Burnt stones suggestive of cooking-hearths.
X.	Pirrian. Stone and bone implements, including *pirri.*	AI.	Occupational debris.
XI.	Pre-Pirrian. Human remains. No stone implements but chippings. Bone implements.	A2.	Occupational debris.
XII.	No implements either bone or stone. Chippings.		

In the succession at Tartanga, the term Tartangan is restricted to the period during which beds E to A were deposited, except AI and A2, the oldest of the series. Hale and Tindale consider the sequence, in ascending order, to be Tartangan, Pre-Pirrian, Pirrian, Mudukian, Murundian, the first-mentioned being separated from the rest by a time-interval of unknown duration.

The sequence with the salient faunas is tabulated

Culture-phases	*Site*	*Salient fauna.*	*Industries*
Late Murundian	Devon Downs I	All are existing species, *Unio vittatus. Melania* much more abundant than *Bulinus.*	Degenerate stone culture. Rock-markings, Type C (illustrated).
Early Murundian	Devon Downs II to IV.	All are existing species of animals *Unio vittatus.*	Degenerating stone industries; adze-stones (*tula*) common only at beginning. Bone artefacts very rare. Rock markings, Type B (illustrated).
Mudukian	Devon Downs V to VII	Small mammals numerous. *Sarcophilus* cf. *harrissi. Unio vittatus.*	Rich stone and bone industries including *tula* and double-pointed bones (*muduk*). Rock markings Type A (illustrated).
Pirrian	Devon Downs VIII to X	Large mammals common *Sarcophilus* cf., *harrissi Chelodina* cf. *expansa, Unio vittatus.*	Rich stone and bone industry. *Tula* rare in upper and absent from lower layers. Leaf points (*pirri*) abundant. Double-pointed bones (*muduk*) absent.
Pre-Pirrian	Devon Downs XI to XII	*Bulinus* much more abundant than *Melania, Unio vittatus.*	Scant bone industry. Stone chippings, but no implements recovered. Not well known.
Tartangan	Tartanga beds. A-E.	*Unio protovittatus.*	Stone and bone industry. Large patinated, discoidal scrapers, coarsely retouched. Coarse bone implements.

Hale and Tindale collected the molluscan shells in the food debris at the Devon Downs Shelter all of which they point out, were brought there. The number of shells of a species found on a cultural level is taken by them to indicate the relative abundance or scarcity of the species in the vicinity at the time, and they show this by a graphical representation of about a thousand specimens of *Melania balonnensis, Bulinus texturatus* and *Corbicula angasi.* They show that *Melania balonnensis* is rare in the lowest layers but in the highest more plentiful; *Bulinus texturatus* and *Corbicula angasi* are plentiful in the lower layers, the former very plentiful, and rare in the higher layers. Incidentally *Melania* is found in the clays with the bones of *Diprotodon* at Lake Callabonna east of Lake Eyre, and is well represented in the warmer rivers of Queensland; Hale and Tindale suggest that its distribution in the layers at Devon Downs implies climatic change "in the direction of the semi-arid conditions of the lower watershed of the present time." The author is of the opinion that the arid conditions at the time of the Postglacial Optimum are indicated. *Bulinus* is a fresh-water genus most abundant in Layer XI (Pre-Pirrian) and its distribution is taken to suggest the cooler climate of the Postglacial that prevailed previous to 8,000 years ago. The relative abundance of the three molluscs seems, therefore, to support the Postglacial climatic changes emphasized here. If the chelonian in Layer X was actually *Chelodina expansa,* such would be inconsistent with them, for that species is only found in northern Australia; it is, however, only compared with *C. expansa.*

It would seem from the physiography of the Lower Murray that all the industries and cultures of Tartanga and Devon Downs belong to the Postglacial period. They have certainly been deposited during a period of accumulation succeeding a period of removal, presumably the vertical erosion accompanying the lowering of sea-level during the last glacial period. That being so, they are certainly Postglacial.

B. Artefacts Associated with Dunes.

Altona Bay is on the north-west shore of Port Phillip Bay, the dune area there extending 3 or 4 miles south-west along the shore from the Kororoit Creek and 1½ miles inland. It has been described and mapped in detail by Hills (1940). Extending along the shoreline is a beach ridge and inland behind this are ridges (referred to here as the inner ridges) of intercalated dune-sand and shell-beds 4 to 5 feet above the floors of the intervening swales. The contained shells are all living species and well preserved; some of them have paired valves. The shell-bed showing in the cutting on the Altona railway line about 200 yards west of the Kororoit Creek, is 8 feet thick and its upper surface is about 9½ feet above L.W.M. (low-water mark at Hobson's Bay—the datum usual in Victoria); it rests on the lava-plain-Newer Volcanic Basalt (Middle Pleistocene). Some layers in it are almost entirely composed of shells, others of fine, loose sand with shells and travertine. Pritchard (1909) states that "there is no hesitation in saying that the shells are marine but occasionally a layer of brackish water shells composed of such genera as *Truncatella, Coxiella, Assiminea, Salinator* and *Ophicardelus* make their appearance." The water in which the beds were laid down was, seemingly, in close proximity to a shoreline.

In the swales there is a small accumulation of sand from the disintegration of the ridges since they were formed. Inland behind the inner ridges are ephemeral lakes—Lake Seaholme, Lake Altona, and Lake Truganina—the bottoms of which are black mud resting on the lava-plain. In the banks of Lake Truganina, 5 feet 9 inches above L.W.M., are marine shells *in situ;* some of the pelecypods are paired. The lower reaches of the Kororoit Creek flow over a similar mud in which marine shells occur. Marine shells are also found in the tidal deposits slightly above present high-tide level on the flats north of the Williamstown Racecourse which is on the right bank of the Kororoit Creek.

The highest inner ridge shown by Hills (1940 Fig. 3) is 10 feet 2 inches above high-tide level, or, as the tidal range at Altona is about 2 feet, 12 feet 2 inches above L.W.M. It is apparent, then, unless there has been very recent subsidence, the inner ridges were submerged to a depth of from 3 to 8 feet by the Recent or Postglacial rise of sea-level of from 15 to 20 feet above present L.W.M. This inundation also filled the lakes behind the ridges. Recent subsidence cannot however be discounted, for the writer (1946) believes that the coastal strip on the eastward side of a line from Footscray to Werribee and beyond is a down-warped area partly responsible for the recent configuration of Port Phillip Bay.

Submergence during interglacial periods has occurred on the Nepean Peninsula, the south-eastern land arm of Port Phillip; there dune-deposits have been levelled and sediments and shell-beds deposited on their levelled surfaces. The succession at Altona is taken to be:

A.—Newer Volcanic Basalt (Middle Pleistocene).

B.—Margaret glaciation period.
- a.—Emergence (W2).
- b.—Submergence (W2/W3). Deposition of shell-beds.
- c.—Emergence (W3). Formation of dunes.

C.—Postglacial.
- a.—Rise of sea-level, progressive submergence and levelling of dunes.
- b.—Maximum rise of sea-level from 15 to 20 feet above present L.W.M. at Postglacial Optimum.
- c.—Progressive emergence. Dunes uncovered with levelled surface, commencement of formation of beach ridge.

The symbols W2, W3 and W2/W3 represent the Wurm glacial and inter-glacial stages.

require investigation by intelligent collecting for evidence of an earlier occupation; such, whether it was positive or negative, would be valuable.

The artefacts found at Altona and Point Cook, on the evidence available, belong to the Murundian, the newest of Hale and Tindale's industries.

C.—Deposits under Lava-flows and Volcanic Ejectamenta.

In Victoria, artefacts have been found under lava-flows and volcanic ejectamenta. Much of the evidence must be accepted on its face-value, for most of the finds were made more than half a century ago. They were found at widely separated places by individuals who, with a single exception, did not realize the significance of their finds: the thought of antiquity never occurred to them. Where possible inquiries have been made by the writer and statements checked. It has been ascertained, for example, that they who were connected with the finding of the Pejark Marsh Millstone (p. 46 *post*) were trustworthy and all of them lived in the locality at the time. It was not possible to locate those who found the Buninyong Bone (p. 50 *post*) but the writer knew the Hon. R. T. Vale who was the parliamentary member for Buninyong towards the close of the last century and chairman of the Board of Directors of the Great Buninyong Estate Mine; he resented any implication that the bone had not been found in the circumstances stated, or that it had been tampered with. The Maryborough Axe was found in 1854. Its authenticity cannot be probed, but it was facetiously queried by a boring engineer who visited the site some 50 years later and gave it as his opinion "that it might have fallen down a wombat hole or a natural hollow." The Colongulac Bone was picked up on the shore of Lake Colongulac together with a number of other bones, including some of *Diprotodon*; it came from a bone-bed that has not yet been located, but is known to occur in the immediate vicinity. There is ground for the belief that the bed is contemporaneous and probably identical with that at Pejark Marsh. Spencer and Walcott (p. 51 *post*) were convinced of the genuineness of the Colongulac Bone. The section from which the Bushfield Axe is stated to have come was inspected by S. R. Mitchell and myself (p. 56 *post*): E. W. Hamilton, who found it, is, too, an untrained observer and his account must also be taken at its face-value. The sole instance of a discovery of implements by a competent and reliable observer was the finding of the Myrniong artefacts (p. 54 *post*) under "The Island" lava-flow; their authenticity cannot be doubted.

If sea-level started to recede 4,000 years ago and it has fallen from 15 to 20 feet at the same rate since, the inner ridges at Altona emerged from 2,400 to 3,200 years ago.

Point Cook, where there is evidence of inner ridges and swales, is topographically and apparently structurally like Altona. The basal bed consists of fluviatile deposits at the mouth of the Skeleton Water Holes.

Both Altona and Point Cook have been prolific collecting grounds for all kinds of stone artefacts. Altona is a growing suburb of Melbourne and the opportunities are fast disappearing; it is deplorable that so few records of the positions of artefacts when they were found have been kept. Enquiries suggest the probability that they were on the surfaces of the inner ridges or the floors of the swales. It will be realized that if any were *in situ* in the surface sand of the inner ridges, such would be evidence of the presence of the aborigines during the last glacial period or the opening stages of the Postglacial. It is obvious from the parallel bedding of the ridges that the whole area was formerly covered by these bedded deposits and the swales responsible for the ridges were formed later. Whether or not the implements found on the floors of the swales were incorporated in the material that has been removed must remain an open question. An intelligent search of the upper sands of the inner ridges would be informative.

At Point Cook, the artefacts are found on the dunes or on the basal bed where it has been exposed by the shifting of the dune-sands. Whether those on the basal bed have been let down on to it by the removal of the dune-sands, or were there before the dune was formed, cannot be determined. The extant native fire-places in the dunes consist of a subcircular collection of fire-stones so placed by the aborigines; they occur at all levels. Where the dune-sand on which a fireplace rested has been shifted by wind action from under it, the stones are scattered, but many fireplaces retain their original shape. At one place the author observed one that had been placed on the basal bed. The fact that they occur at different levels might be taken as evidence that the aborigines were there throughout the whole dune period and even before, but there is the possibility that they selected a depression, or made one, in which to place their hearths; if so, they could be readily covered by drifting sand.

Summarizing these notes, up to the present, the evidence at Altona and Point Cook points to the earliest occupation of those areas by the aborigines about 3,000 years ago, when the inner ridges at Altona were first uncovered. The beds in the areas

The volcanics of western Victoria may be considered under two headings—the earlier lava-plains phase and the recent scoria-cone phase, the latter comprising scoria, scoria-cone lava-flows and tuff.

The lava-plains or lava-field phase extends westwards from the meridian of Melbourne to near the western Victorian border; it is bounded on the south by the Otway Ranges and further west by the Southern Ocean, the coastline of which is fringed with dunes. It extends northwards almost to the Dividing Range in its former position. No artefacts have been found under it, but an understanding of its place in regard to the scoria-cone phase is desirable.

The scoria-cone phase is, from the standpoint of archæology, highly important, for under some form of it have been found the Pejark Marsh Millstone, Buninyong Bone, Maryborough Axe, Bushfield Axe, and the Myrniong implements. The most comprehensive survey of both of these volcanic phases is that by Grayson and Mahony (1910) who mapped in Quarter Sheets 8 N.E. and 8 N.W. (New Series) over 580 square miles and described the area. The legend of these Quarter Sheets does not give geological ages for any of the features mapped other than the basal marine sediments on which the lava-plains rest. The legend given in Fig. 4 is compiled from their statements and our own observations.

Age	Quaternary Periods	Soils, Clays, Tuffs and Gravels			Volcanic Phases	Climate and Rainfall
RECENT	Postglacial	Black alluvial soil Dunes of quartz sand and redeposited tuff Hampden tuffs Black clay containing wind-blown sand and tuff Diprotodon Bed Yellow clay of wind-blown sand and tuff Buckshot gravel	Surface flood-plain ↑ Sub-surface flood-plain	Surface lacustrine ↑	scoria cones, scoria cone flows & tuffs	increasing rainfall arid period postglacial optimum decreasing rainfall
PLEISTOCENE	Margaret glacial		↑ Vertical erosion	Sub-surface lacustrine		cool, rainfall period
	Yolande-Margaret Interglacial	Buckshot gravel				increasing rainfall arid period decreasing rainfall
	Yolande				[lava plain]	cool, rainfall period

FIG. 4.

Legend compiled from Quarter Sheets of Camperdown and Mt. Elephant Districts.

Grayson and Mahony state that the scoria-cones and scoria-cone flows are of very recent origin, and though they are "approximately of the same age, some of the flows are no doubt considerably older than others, and no sharp line can be drawn between them and the earlier [lava-plain] basalts." Nevertheless, that there is a time interval between the scoria-cone phase in the Camperdown district and the lava-plains, is evident from the fact that while no scoria-cone flow shows sign of fluviatile dissection, the stream-system on the lava-plains is mature.

Earlier accumulations of the Hampden Tuffs, a tuff-series so-named by Grayson and Mahony, cover extensive areas near Camperdown and Lake Keilambete as well as the floors of Lake Bookar and Lake Terang. Since it covers the floors of these and other lakes and swamps, their basins were formed either during or before its accumulation. Its earlier phases are distinct from the scoria and scoria-cone lava-flows which in places rest on it, while it in turn rests on the mature topography of the lava-plains. The time taken for the lava-plains physiographical cycle to reach maturity is the interval between the accumulation of these earlier phases of the Hampden Tuffs and the extrusion of the lava-plains.

That the final accumulations of the Hampden Tuffs are quite recent, is shown by their position in the Pejark Marsh section (Fig. 5) where the series is covered by only 3 feet of soil; there it is only 2 feet thick and the attenuated edge of a thick series of tuffs on the slopes of Mt. Terang (*cf.* Walcott, 1919), it rests on black clay which rests on yellow clay that also contains volcanic ejectamenta. The texture of this yellow clay suggests that it was deposited during the the arid period of the Postglacial Optimum, and the black carbonaceous clay resting on it was deposited after the Postglacial Optimum. From the evidence afforded by the beds in the Pejark Marsh section, it appears that the scoria-cones in the area were active during the arid period and spasmodically during the increasing rainfall period up to less than 2,000 years ago, when, approximately, the Pejark Marsh Tuff accumulated.

Gill (1943) points out that the tuff at Warrnambool is of very recent age, and gives as part of his evidence that it rests on Holocene shell-beds which means that the tuff is later than at least the beginning of the Postglacial recession of the sea (if the 15-foot relative rise of the land at Warrnambool is due to this cause). The writer, on the other hand, believes (p. 58 *post*) that the Warrnambool tuffs accumulated earlier in the more recent half of the Postglacial.

The Hampden Tuffs, in most places, rest on buckshot-gravels of lateritic origin formed during the tropical and subtropical climates of the arid periods of the Postglacial and interglacial stages. The flood-plain deposits of the mature Emu Creek are at no place covered with scoria, a scoria-cone flow or tuff; they seem to have been at all times beyond their reach.

The lacustrine sediments in some of the oldest depressions on the lava-plain have been accumulating since the lava-plain was formed. The flood-plain deposits commenced to form after these older depressions were connected up by the dissection of the lava-plains, and continuous drainage channels formed; it is possible that some of the sub-surface flood-plain deposits rest on the earlier lacustrine deposits. As both lacustrine and flood-plain deposits are still accumulating in places, the surface deposits of each are Recent and contemporaneous; below the surface parts of each are also contemporaneous but their respective positions in terms of footage are in no-wise comparable. Lacustrine sediments on this area are mainly composed of wind-blown material and accumulate at a much slower rate than the fluviatile sediments: a few feet of the first may be represented by many feet of the second—there is no way of equating the deposits except at the surface.

The valleys of the mature topography show some evidence of terracing, but these have not been correlated with any Pleistocene eustatic levels. From the mouth of the Hopkins River to Cape Otway, the coast is a young, receding one, with cliffs up to 100 feet high of horizontal Tertiary beds capped with dune-limestone. On the face of these cliffs are remnants of the 15 to 20 feet Post-glacial raised beach, but the Pleistocene shorelines have either been removed by erosion or are submerged under the waters of the Southern Ocean.

Included here with the scoria-cone phase are the confined lava-flows that extend as tongues down valleys falling both north and south from the Dividing Range in its present or former positions. Most of these flows belong to the scoria-cone phase, but, where the lava has poured on to the lava-plains from the scoria-cones, it is difficult to distinguish it from the older flows.

The facts concerning the discovery of the Pejark Marsh Millstone were stated by Spencer and Walcott in their unpublished manuscript on early man in Victoria (1914 *circa*). As they made personal contact with the finder who gave them all the particulars, they were best fitted to describe the circumstances of the find and to form an opinion as to its authenticity. Their remarks are quoted *in extenso*:

In the beginning of February 1908 we received from Mr. A. J. Merry of Terang, a letter in which he states "I am forwaring some bones and what I think is a stone implement I unearthed in an excavation for a concrete culvert, over a drain, half a mile from the township (Terang) and 2½ miles this side of Mount Noorat. . . . . The excavation was about 10 feet deep from the natural surface, and consists of 3 feet soil, 2 feet solid sandstone, 3 feet black clay, 2 feet yellow clay, as far as I had to go down. Through the whole length of the trench—69 feet—in the yellow clay were pieces of bone in nearly every shovel full, samples I am forwarding you. [Mr. Merry says in letter 23 July '09 that bones also in last foot of black clay.] I have been told by men who excavated the drain in the first place, that from end to end about 2 miles in length, they took out bones in cart loads and all in the clay, some feet under the sandstone.'' . . .

In reply to questions Mr. Merry adds, ''The implement was embedded with the bones in the yellow clay, it was impossible for it to have fallen in from the overlying beds and I was very careful with it, as when I struck it with the shovel I thought it was a large bone, and wanted to get it out without breaking it. It was 3 feet in from the bed of the drain, and 2 feet below same in the solid clay under the sandstone 3 feet in width which I had cut away.''
In a later letter he states ''I showed it to Dr. Breaton [*sic.*] in its rough state at the works with the yellow clay adhering to it, and he did not notice that it was an implement. I then took it home and washed all the clay off it, and could see that it was a piece of stone implement.'' Mr. Merry also states that well sinkers have found bones at depths of over 100 feet under the ''sandstone'' bearing out his experience quoted before. Mr. R. Harvie, one of the men who worked in the opening of the drain in the first place, informed Mr. Merry that he dug up a stone implement, said to be a grindstone, about a chain below the culvert, 9 feet from the surface, which is about the top of the yellow clay, and 4 feet below the ''sandstone.'' He also told Mr. Merry that they dug up a ''Petrified Skull'' with the teeth intact, but they placed no value on it, and after knocking the teeth out, threw it on one side. This skull was found about 100 yards to the west of the culvert with a number of fossil bones just on top of a bed of ''buckshot gravel'' about 5 feet under the ''sandstone'' . . . . In another letter Mr. Merry writes ''Whilst removing some clay I had previously thrown out from the excavations I came on another broken implement, this time of a dark blue colour. . . . I missed seeing it when I first threw it out, I think it must have been in a big spit, and the clay all round it hid it from my view.'' Although he does not know what part of the trench it came from he is positive it came from below the sandstone. It should be mentioned here, that the sandstone Mr. Merry refers to is not sandstone but a compact bedded tuff which is locally known as sandstone.

We have no reasonable cause to take exception to the authenticity of the first implement found by Mr. Merry. He is a man whose statements are reliable and who had, moreover, no knowledge of the interest attached to the discovery, and personal enquiries only bore out the correctness of his statements. The only doubt then must be as to whether the implements could possibly have fallen in the trench from above. Mr. Merry is most emphatic that such was not the case and as the bottom of the trench was lower than the drain and bones were also found with the implement there can be no doubt that the ground has not been disturbed since their deposition. . . .

The other implement found by Mr. Merry and described by him as being of a ''dark blue colour'' is formed of a small boulder of fine-grained laminated basalt. It weighs about 3¼ pounds and represents roughly a little more than half the boulder. It has been roughly chipped on both sides of one end to produce a rough cutting edge, forming a by no means uncommon implement called by Messrs. Kenyon and Stirling in their scheme of classification an axe chipped on both sides. With the exception of a fracture made by Mr. Merry, the surface is of a dull light bluish-grey colour, due to weathering. The variety of basalt is quite distinct to that occurring locally and the fact that the implement has been made from a boulder proves that its source must have been the sea coast or a distant watercourse. Its antiquity would be quickly disposed of if the origin of the stone were known for the newer lavas of the Hampden [area] are in all probability younger than the tuffs. As, however, the implement was not found *in situ* it cannot be used in support of the antiquity of man in Australia . . . . .

The following is a composite section based on observations by Merry, Spencer and Walcott, and the writer.

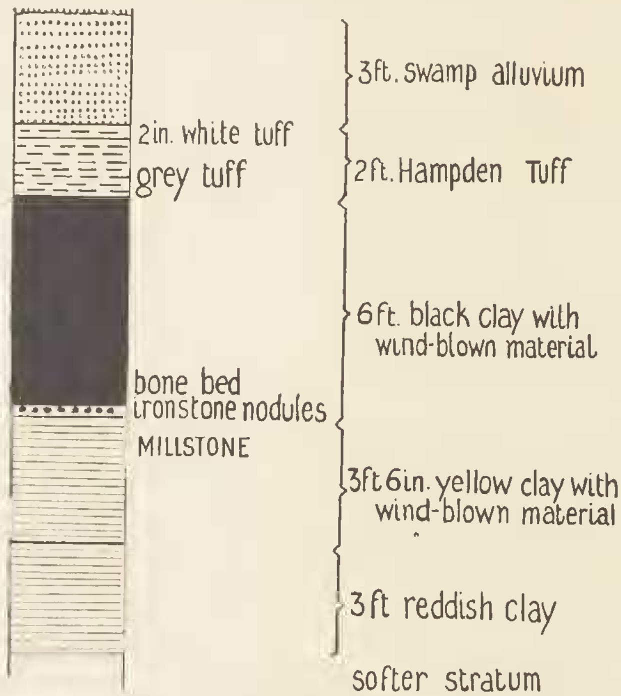

FIG. 5

Composite Section of Excavations made near drain in Pejark Marsh.

Pejark Marsh is an irregularly shaped fresh-water swamp that has been drained, about 440 feet above sea-level, in a depression between the scoria-cone of Mt. Noorat (1,026 feet) about 1½ miles north of it, and Mt. Terang about 40 chains south of it. Before it was drained, it was covered with thick ti-tree scrub and eucalypts. To the east and west, the surface is covered with buckshot-gravel, and there is a narrow strip of buckshot gravel on its northern margin where the scoria-cone flow from Mt. Noorat almost reaches the Marsh. On its southern margin are the lava-plains basalt and Hampden Tuffs.

The country surrounding the Marsh is generally flat, Mt. Noorat and Mt. Terang providing the only relief. No streams have at any time emptied into the Marsh and the water it contained was the rainfall that fell over its restricted basin. The surface-soil and black clay are rich in carbonaceous material indicating the existence, when they were formed, of a swamp-flora flourishing in a climate with moderate rainfall; on the other hand, when the yellow clay was deposited these conditions did not exist and no carbonaceous matter was found in it.

In 1908 Spencer and Walcott (1911) made an excavation near where Merry reported his find in search of implements but found none. The succession passed through confirmed that reported by Merry.

With the same object in view, it was decided to seek the permission of the Shire of Camperdown to put down a hole near Merry's original site. Mr. Rooney, the Shire Engineer, instructed Mr. Blackburn to do this for the Museum. The site selected was in the drain on its northern sloping bank on its south side, a few yards from the old culvert and between it and the new one over which the stock-route passes.

The hole for the Museum was put down early in 1947. Except that the thickness of the beds varied, the succession confirmed that given by Merry and Spencer and Walcott and shown in the composite section (Fig. 5). At the bottom of the black clay, the bone-bed was passed through and in it a molar, a lower incisor, and part of the diastema of *Diprotodon australis* (Owen) were found. Elsewhere, the writer (1945) has placed the *Diprotodon* bed of Grayson and Mahony above the Hampden Tuffs but here it is, at least apparently so, below part of them. In the lower layers of the tuff itself numerous examples of the reed *Cladium tetragonum* (Lab.), the black, square Twig Rush, were identified by J. H. Willis, of the National Herbarium; their presence had been previously noted by Walcott (1919). Pressed against the bedding-planes, their method of preservation suggests that they had been flattened under successive accumulations of tuff, and although the explosions responsible for the bed of tuff occurred over a relatively short interval of time, they were spasmodic. In one of the lower layers of tuff a fossilized insect larva was found; this was identified by A. N. Burns, Entomologist to the National Museum, as approximating to *Oxycanus fuscomaculatus* Walk. It was replaced by a fungus also identified by Mr. Willis as *Cordyceps* cf. *lavarum* Olliff, the mycelium of which permeated its tissue and facilitated fossilization. During the accumulation of the tuff, the swamp-depression, although damp—the reeds evidence this—apparently seldom held up water. To permit of the metamorphosis of *Oxycanus,* the floor of the swamp must have been exposed in May and June, at present wet months in this region; the loose aggregation of the tuff seemingly made it extremely porous.

semblance to a bone-implement made by the aboriginal and "probably not by any more primitive forerunners." He states that "the cuts were manifestly made by a steel-edged implement, such as a shovel, which crushed and broke crystals of pyrites filling the interstices of the cancellous tissue. This was conclusive proof that the cuts had been made after pyritization of the bone, which must have taken place after immersion in the sub-basaltic river gravel and the contained mineralized waters." Kenyon made this statement 34 years after De Vis, who saw the bone in its original condition, had declared it was an implement fashioned from a portion of a rib of a *Nototherium* (De Vis, 1900). De Vis was an authority on the cuts made on bone by predatory animals and he examined closely the nature of the cuts; he did not refer to the state of the pyritic impregnation. Spencer and Walcott (1914 *circa*) also specialized in cuts made on bones by animals and they state that they were convinced that some of the cuts were the work of *Thylacoleo,* but others were not. They state that "the late Dr. A. W. Howitt, who had the opportunity of seeing the Buninyong Bone before it was coated with size to preserve it, informed one of us that he was quite satisfied that none of the marks were of recent origin, and that they had one and all been made before the bone was deposited where it was discovered. This statement of Dr. Howitt's seems to be correct from the general aspect of the marks, and Mr. De Vis has corroborated him by making a cut in the bone himself for comparison." They scout, too, the suggestion by Gregory (1904) that the bone may be the result of an accident, the shovel of one of the miners having possibly cut into the bone and broken it where it was lying in the silt, the shovel at the same time having driven mud into the cut-surface thus hiding its recent formation. Anyone who has carefully studied the bone, they say, could not possibly give any credence to such an explanation "for the shovel has not yet been invented which could produce accidentally marks of this kind." But they consider that the fact that there is no record concerning the whereabouts of the bone from the time it was found until it came into the mine manager's hands is a flaw in the chain of evidence regarding its authenticity.

De Vis thought the implement was a scraper but Spencer and Walcott considered it extremely doubtful that the specimen was ever intended for use: Howitt expressed no opinion as to its purpose.

The section in the Great Buninyong Estate Mine shown in Fig. 6 was compiled from particulars given by Hart (1900).

Mrs. Sylvia Whincup, Mineralogist to the Museum, separated out the minerals composing the yellow clay. Quartz-grains were common, the larger well rounded, the smaller angular; clear quartz was abundant and reef-quartz common. Other minerals present were magnetite, olivine, and volcanic glass indicating that a scoria-cone was in action while the clay was being deposited. She also found zircon, tourmaline, and rutile—minerals that have obviously been transported from some distant source. In view of the fact that no streams now enter, or have entered Pejark Marsh in the past, one can only assume that these minerals are wind-borne. A small microscopic freshwater shell found in the clay may have had a similar origin.

The Pejark Marsh succession is typical of surface and sub-surface transported deposits on other parts of the lava-plain. The records of a number of bores put down through such, show that the surface to some depth consists of dark or black sediments under which is a yellow clay.

Howitt (1904) attributes to James Dawson the tradition of the aborigines of western Victoria that fire came out of a hill near Mortlake, and "stones which their fathers told them had been thrown out of the hill by the action of fire." If there is an historical background to the tradition, Mt. Shadwell is the nearest scoria-cone to Mortlake, but Noorat, Keilambete, and Terang are all vents not far distant.

Summarizing the evidence that has accumulated in connection with the Pejark Marsh Millstone, it may be confidently stated that it is of Recent or Postglacial age. The yellow clay in which the Millstone was found is covered by black clay, bedded tuff, and soil, that have been deposited up to the present time without a time break, but there may have been a short time interval between the yellow clay and the overlying black clay. Estimated by the measure of climate, the millstone is less than 3,000 years old, having been covered by the wind-borne material at the concluding phase of the arid period of the Postglacial Optimum. It belongs to some horizon of the Murundian in Hale and Tindale's succession (*supra* p. 38).

The Buninyong Bone (Plate 2, Fig. 8) was found in the Great Buninyong Estate Mine at Buninyong, near Ballarat, towards the close of last century. Apart from the question of its authenticity, a doubt persists as to whether it is an implement and has been fashioned by man.

Kenyon (1936) claims to have examined it "while it was still in a fairly fresh state." He condemned it because it had no

He states that the lava-flows from Mt. Buninyong that covered the lacustrine clays need not be of any great age. That the clays are quite recent is evident from the fact that the Buninyong Bone was a portion of the rib of *Nototherium;* the bones of *Nototherium* are sometimes found under a scoria-cone flow but never under the older flows of the lava-field or lava-plains. Mt. Buninyong is a scoria-cone from which the lava Hart mentions flowed down a valley that formerly emptied its drainage into the Murray but was later reversed and became part of the drainage-system to the Southern Ocean. The black, lacustrine clay was deposited in a depression which was covered by the lava; the age of the clay is nearly that of the overlying scoria-cone flow. The black clay was

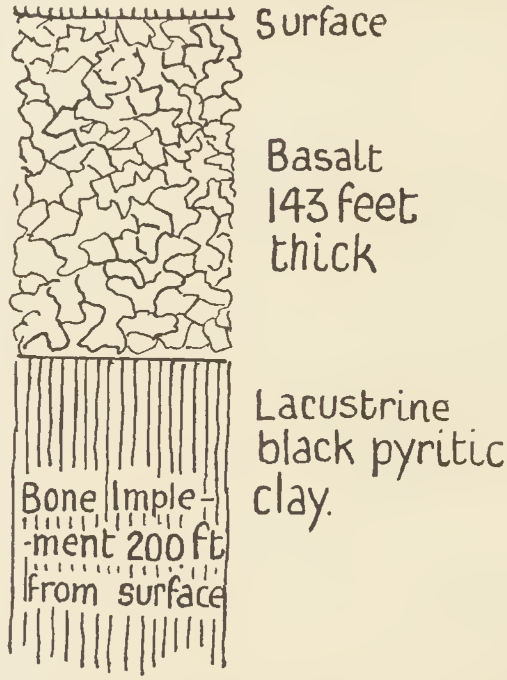

FIG. 6
Section in Great Buninyong Estate Mine.

deposited during a period when the rainfall was great enough to support a humus-forming vegetation. Such conditions prevailed during the earlier part of the Postglacial and the last glacial period. The yellow clay of Pejark Marsh is not present in the Buninyong section, and the black lacustrine clay appears to have been covered by the scoria-cone flow before the dry period of the Postglacial Optimum.

Lakes such as that in which such lacustrine deposits formed have been common in the district but most of them have been emptied by the breaching of their perimeters. Baragwanath

(1923) states that west of Mt. Buninyong, in the Yarrowee Creek valley "a small lake was formed against the basalt . . . its surface showing at about the 1,290 ft. contour at one period; whether it was the original limit cannot be settled. Abundant chips such as are found at the sites of aboriginal camping-places occur along the former shore-line, and clearly mark points where the natives congregated, but above or below this limit the chips are rare." Mr. Baragwanath took the writer to the locality but it has, since the former made his observations, been planted as a pine forest and the evidence is not now obtainable.

It is interesting to note that Howitt (1904) states that there was an aboriginal tradition "that Mount Buninyong had at a distant time thrown out fire."

On the scanty evidence available, the Buninyong Bone possibly belongs to the Tartangan of Hale and Tindale's industries (*supra* p. 38).

In 1855, A. C. Swinton and M. C. Shore sank a shaft near the town of Maryborough, Victoria, in one of the heads of the tributaries of the so-called Bet Bet Lead. A lead is the lowest fluviatile deposit in an old river-valley usually covered by later fluviatile deposits but often with lava. The Bet Bet Lead was formerly thought to occupy a single trunk-valley having an outlet to the north-west, but it has since been found to consist of two valleys falling in opposite directions, one towards the Avoca Lead, the other towards the Berry-Moolort-Loddon Lead System.

Swinton and Shore's shaft was sunk for a depth of 5 feet to "bottom," presumably Palæozoic bedrock. At a depth of 4 feet from the surface, Shore drove his pick into a basalt axehead (Howitt, 1898). The shaft had passed through a hard band of cemented gravel and also three "false bottoms." A false bottom is a stream level above the lowest fluviatile deposit at which former fluviatile deposition has occurred. The presence of three of these in a depth of 5 feet below a surface deposit accumulating at the present time, points to three very recent, short-lived cycles of erosion. We are not told whether the axehead was in false bottom material, but the shallow depth involved and the position at which it was found, suggest this.

It is not possible now to pin-point the shaft on a map, although for our purpose, its position in relation to the local physiographical divide is important. If it was on the west of the town, the fluviatile sediments belong to the westerly stream-system; if on the east of it and in a tributary flowing northerly or easterly, they are part of the eastern stream-system. Both these systems formerly emptied into lakes and the sediments now covering their lower reaches are covered with lava. The scoria-cone flow over the western one is evidently very recent, for the subsequent streams have not yet become marginal streams; the lava in places is a narrow flow that appears to have occupied a small gutter cut in fluviatile deposits. The lava covering the sediments over the eastern trunk-stream appears, on the other hand, to be older, for fairly mature lateral valleys have been formed along its margins. Some of the tributaries of this eastern trunk stream have been dammed back by encroaching lava, a lake has been formed, and lacustrine sediment deposited on the tributary flood-plain. Such has occurred at Talbot (Back Creek) 8 miles to the south, where the remains of *Diprotodon* were found supposedly in diatomaceous lacustrine deposits (Keble, 1945).

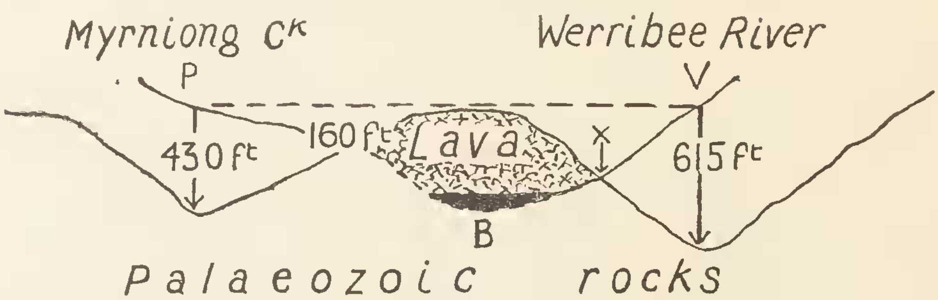

FIG. 7.
Section through The Island, Myrniong.

The absence of information as to what bed the axehead came from makes its age uncertain but the geological history of the area indicates the Recent or Postglacial.

The Myrniong implements from The Island, 6 miles N.W. of Bacchus Marsh, were found in a bed of gravelly clay (X, Fig. 7) 18 inches thick underlying basaltic lava, by C. C. Brittlebank, Government Plant Pathologist, who was also a skilled and reliable geologist. The Island is so-called because it is a high lava-residual almost separated from the rest of a scoria-cone flow by the deep erosion of marginal valleys, the streams in which almost junction at its north-west end and actually become confluent to the south-east of it. A section of the lava-residual is shown in Fig. 7.

The pre-basalt valley, PBV in Fig. 7 was filled with basaltic lava to the level PV after which, to find an outlet, the drainage started to erode in the less resistant rocks at P and V, channels that have developed into deep marginal valleys. That developed at P, the Myrniong Creek, is now 430 feet below the original surface of the infilling basalt, and that at V, the Werribee River, 615 feet below it.

It is apparent, and Brittlebank realized this, that if the rate in years of the erosion of the marginal valleys could be determined, it would be possible to ascertain the age of the basalt, and with it the age of the gravelly clay and the age of the implements. He experimented (Brittlebank, 1900) by inserting short lengths of wire in holes bored in the rock at the bottom of each of the valleys and recorded the times when a particular length was exposed. He obtained a rate of erosion of 0·58 in. per century, which, applied to the mean depth of both valleys, gives an age of over a million years. Apart from the crudity of the experiment, which ignores a number of factors, the main objection is that it was conducted at a time when the rate of erosion was near its minimum—a short lapse of time after the Postglacial Optimum. The rate of erosion had consistently decreased up to that time, and its mean was formerly very many times greater than the figure obtained by Brittlebank.

The basaltic lava of the Bacchus Marsh district issued either to form extensive lava-fields, or scoria-cone flows that occupied pre-existent valleys, at various times from the Middle Pleistocene (Keble, 1946) up to a recent period in the Postglacial. Those of The Island were scoria-cone flows having their main source at Mt. Blackwood (Fenner, 1918). They infilled the channel PBV, the middle reaches of a valley that opened, about a mile S.E. of Rowsley, on to the Werribee Plains lava-field. Across this opening is the Rowsley Fault trending S.S.W. Fenner (1918) gives sections across the fault showing the displacement or otherwise due to it. Near Dog Trap Gully, east of Rowsley, about where the Island flows debouched on to the Werribee Plains lava-field, he shows (*sup. cit.* Figs. 7, 8b). The Island scoria-cone flows pouring *over* the scarp of the fault, but south of the Anakies (*sup. cit.* Figs. 7, 8d) the fault displacing the lava-plains basalts. He refers to a post-Newer Basalt movement and it is apparent from his Figs. 7, 8d, that this occurred after the Werribee Plains lava-field, but it is apparent, too, that it was before The Island scoria-cone flow poured over the scarp near Rowsley. The Pleistocene movement on the fault is newer than Middle Pleistocene and The Island lava possibly late Pleistocene but probably Postglacial.

The erosion of the marginal valleys of The Island—the Werribee to a depth of 615 feet and Myrniong Creek to 430 feet, has been taken as evidence of their great age as well as that of the infilling basalt. That this is not necessarily so, is apparent when one considers the Bullengarook lava-residual, 8 miles to the east, which has many features in common with The Island. There the marginal valleys, Goodman's Creek and Coimadai Creek, have been cut to a depth of over 400 feet below the original surface of the Bullengarook scoria-cone flow. The limestone at Coimadai was deposited in one of the marginal valleys and according to Coulson (1924) was chemically precipitated in a small lake just before, during, and after the eruption from Mt. Bullengarook. The lake was probably formed by the damming of a lava flow (Keble, 1945). Its recent age is indicated by the occurrence of the remains of *Nototherium* in it.

There is the possibility that the Myrniong implements were buried in a cache, a common practice among the aborigines, particularly with stone axes; in view of the fact that more than one implement was found, this seems improbable. A doubt, too, has been expressed by a few archæologists that they are implements at all, but they have been accepted by most.

FIG. 8.
Section in the hole at Bushfield.

If The Island basaltic lavas belonged to the lava-plains phase the age of the implements would be over 200,000 years! Their occurrence under a scoria-cone flow makes them probably early Postglacial and no older than any of the more ancient implements found in Victoria. They presumably belong to one of Hale and Tindale's earlier industries, perhaps the Tartangan.

The Bushfield Axe was found by E. W. Hamilton, of Warrnambool while he was sinking a hole to a depth of 8 feet on the right bank of the Merri River to anchor a power-winch to clear the bank of the river of trees. The site of the hole was about a quarter of a mile north of Bushfield, on Allotment I, Parish of Meerai.

Mr. S. R. Mitchell examined and checked with me the section in the hole shown in Fig. 8, in which tuff rested on tuffaceous limestone in which the axe was found.

The tuffaceous limestone is a lacustrine deposit which, when it was formed in the lake, incorporated the tuff falling at the time.

Miss J. Hope Macpherson, conchologist to the National Museum, has identified the land shells found in it as *Ameria acutispira* Tyron and *Lymnaea brazieri* Smith, forms found in slow moving water or a marsh.

The hole was put down in an accumulation (Fig. 9, YDZ) of stratified tuff and tuffaceous limestone on a river-terrace, C (Fig. 9) that was formerly covered by 5 feet of stratified tuff, now removed by slip-erosion. The axe was found at a depth of 3 feet 9 inches, but its original depth, when the uppermost stratified layers, D (Fig. 9) covered it, was about 9 feet.

It was not possible to obtain a single section giving all the features in evidence. Fig. 9 is a composite section.

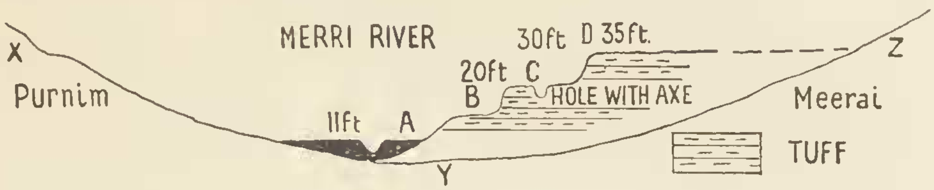

FIG. 9.

Composite section across Merri River in the direction of a fence-line on the left bank bearing N. 53° E.

The succession of events may be summarized as follows:

The valley XYZ was cut in Tertiary limestone, probably during the last glacial period, and was periodically covered during the Postglacial by tuff from Tower Hill, 7 miles to the west, until the tuff reached the level XDZ. While the valley XYZ was being infilled, the Merri River continued to flow, although it was from time to time impeded by the accumulating ash when lacustrine or marsh conditions prevailed. It ultimately cut the channel XYD along the eastern contact of the tuff with the Tertiary limestone to a depth of 40 feet below the surface layer XDZ. In this channel, the flood-plain A, about 150 feet wide, formed and has since been entrenched to a depth of from 15 to 16 feet by the vertical erosion following the last lowering of sea-level. The surface of the flood-plain was at the time of inspection 11 feet above the level of the water in the Merri River, which was 4 or 5 feet deep; the bed of the River opposite the hole in which the axe was found is about 30 feet above the level of low water at Warrnambool Bay. The time taken for the accumulation of the 9 feet of tuff covering the axe together with that taken for the valley XYD to reach maturity is the age of the axe. The flood-plain A was formed at or about the Postglacial Optimum, probably just before the rising sea-level of the Postglacial reached its maximum, and after Tower Hill had ceased to be active: the vertical erosion of the Merri

River preceding its formation was contemporaneous with the concluding stages of the Tower Hill activity. It is therefore apparent that the axe is more than 4,000 years old, and allowing for the maturing of the valley XYD, its age is perhaps 6,000 years. The appearance of the sides of the hole sunk for the power winch exclude the possibility of its having been from the surface in a cache.

The axe (Pl. 2, Fig. 7) was of basalt and not complete. It has a cutting-edge that may have been polished but now shows no sign of it, and a hafting-groove towards the head, most of which is missing. It shows slight signs of patination but there was not adherent matter; possibly the ash-matrix was not adherent. Before it was covered with the uppermost layers of tuff (D. Fig 9) it was, doubtless, lying on the surface exposed to the elements.

Mulder (1904) states that the meaning of native names for our volcanoes indicates smoking, hot, ground such as Koroit [Tower Hill] "suggesting that the natives saw the volcanoes when in action, but at a period so remote that even the tradition had died out, the names only surviving." This has been questioned but legends—some have been already given—relating to volcanic activity have been recorded from so many of the tribes who lived on the lava-plains and among the scoria-cones of western Victoria, that there seems to be a germ of truth in them. That the aborigines could visualize volcanic activity without some of them having seen it, is inconceivable.

Mr. Morgan, the owner of the property on which the axe was found, stated that he found an axe in the tuffaceous limestone where it is exposed on the side of the valley XYD with limy material adhering to it; he threw it into the river.

The period when the Bushfield Axe was used is contemporaneous with one of Hale and Tindale's middle industries, but precise correlation is impossible.

Summarizing the evidence of the artefacts found at Tartanga and Devon Downs in South Australia, and those associated with dunes and the volcanics of Victoria, such points to a Recent or Postglacial age for them. In view of this, discussion here mostly concerns climatic change during the Postglacial.

IV. Bones Shaped by Man or Animals

It must be conceded that Spencer and Walcott (1911) make out a case for cuts on the bones of marsupials having been made by the carnassial of *Thylacoleo*. In this they follow in the wake of De Vis, whom they freely quote; he had long recognized the work of the teeth of that animal and was pre-eminently fitted to judge which cuts on the Buninyong Bone could be ascribed to it, and which to human agency. His discussion (De Vis, 1899) on the shaping of the bone is pertinent to a general discussion of the shaping of bone artefacts and is given here at some length.

De Vis's figures 1 and 2 are reproduced here as Fig. 8, Pl. 2.

. . . . At first sight the fossil appears to have been intentionally shaped to adapt it to some instrumental use. It may, then, be convenient to confirm the first impression by pointing out the marks of human workmanship which it has, with more loss [*sic*] certainty, preserved to us. It consists of part of the distal half of a right rib, the seventh or eighth, of an animal so large that it could only have been one of the greater *Nototheres,* in all probability *Nototherium mitchelli* Owen. It is perfectly mineralized in the usual manner, differing in no wise in texture and colour from the well preserved contemporary fossils found elsewhere. . . The length of the fragment is 154mm.; by the loss of its central edge, which has been split off, its greatest breadth has been reduced to 42mm. On its posterior aspect (Fig. I), there is at (a) an obvious flattening of the upper part of the blade, the surface of the bone for a length of 65mm. having been removed to an appreciable depth, and apparently by some mode of abrasion; near the distal end of the split edge on the same side appears a marked hollow (b), at the bottom of which the cancellous structure of the interior of the shaft has been by the like means brought into view.

So far the abnormal features observable are not of intrinsic importance. They may have been the result of ordinary physical agencies of attrition. A similar explanation of the condition of the lower end of the bone, or at least of one edge of it, is, on the contrary, inadmissible. On its posterior face (Fig. II) the rib has here been half sundered by a cut through its dense cortex (c) effected by strokes of a sharp instrument. A little lower down on its opposite face (Figs. I and IId), it has been divided to a large extent, and the part beyond the two nicks so made has broken off, the line of fracture naturally occurring between them. The extreme edge of the fracture was brought to coincide with the inner edge of the lower nick and this consequently presents a fairly sharp edge, rendered somewhat jagged by adherent remains of the internal cancelli. The surface of the lower nick (Fig. Id) is convex in both its directions of extent, but whether this rounding off is the result of an original method of formation by filing, scraping or shearing tool, or by the subsequent grinding of a surface in whatever way produced, is not to be gathered from the existing surface. In the latter case it is of course quite possible that this bevelled surface also might have been the outcome of mere physical action of a piece of rib lying in a watercourse or sand drift with one end partially exposed; it is even possible that the severance of the bone on this side of it was due to such cause. But these conjectures seem to be entirely forbidden by the complete absence of any sign of abrasion on the inner surface of the edge of the nick; the broken walls of the bone cells, even at its extreme edge, are as sharp and prominent as they were left by their fracture, and we are therefore driven to the conclusion that this surface, however formed, was intentionally formed. That the surface of the upper nick—that on the opposite side of the bone (Fig. IIc)—could not have been yielded by any physical process, is on the other hand unquestionable. It is certainly the work of an animal possessed of a chopping instrument, and as far as we know the only animal of the age of the *Nototherium* that can excite even a passing suspicion is the so-called Marsupial Lion, *Thylacoleo carnifex* Owen, a confirmed bone-eater, with enormous shearing teeth. With the ossifragous capability of *Thylacoleo* we are not at this day unfamiliar, and experience makes it quite safe to say that the bone was not cut by the molars of that animal.

Powerful as its jaws undoubtedly were, they have left no evidenee that they were able to cut through dense bone to any considerable depth, certainly not to a depth of 3mm., as in the case before us. They chopped the surface (generally on opposite sides) but slightly, to a depth of a millimetre or so at the most, and by the impact of the blow or by continued effort crushed the bone in twain. The form of the ineision is in itself sufficient proof that it was not the work of *Thylacoleo.* Its outer or upper edge, crossing the rib obliquely, is irregularly undulating, its surface inclined, from without inward to an open angle, shows under a eertain incidence of light, three shallow, unequal undulations, or rather subeonehoidal depressions which could have been sculptured by an instrument having a strong bevel above its cutting edge. The surface of wear of the molars of *Thylacoleo*, which so frequently leaves its impression on the substance of long bones subjected to their action, is level, except that occasionally it is more or less distinctly bevelled off at its posterior end; the cut effected by it across the shaft of a bone is therefore a straight-edged and flat-surfaced notch. Of producing one with an edge which is even slightly scalloped and with a broad oblique surface of conchoidal facets, it is altogether incapable. We have, therefore, to fall back on an unknown user of an instrument adequate to the purpose, and this could not well have been any other than man. If now we are prepared to accept the view that this bone was wrought by human hands, and for the nonce assume the genuineness of the fossil, we shall have little diffieulty in understanding how and why it received its shape. We may infer that the upper nick was first made; afterwards, and probably with the same instrument —a small, sharp stone tomahawk—the lower nick; the bone then broken between them, and the lower end ground with a bevel to obtain an edge which should be curved, moderately sharp, and rather rugose.

The Buninyong Bone is in the collection of the National Museum, Melbourne, and was available to Spencer and Walcott, who were members of the staff of that institution. They (1914 *circa*) sum up their conclusion in the following remarks:

> The more carefully and the longer we have examined the specimen especially in the light of bones, the cuts and marks on which we feel convinced have been made by a predatory animal, the more certain we feel that the only remaining alternative—human agency—must be invoked to aceount for the origin of some of the eharaeters exhibited on the specimen.

This conclusion was arrived at after they had made an exhaustive study of all kinds of cuts on marsupial bones. In a contribution (Spencer and Walcott, 1911) giving the results of their research, they deal mainly with bone fragments obtained at Pejark Marsh by A. J. Merry with the millstone found by him, and other bone fragments obtained there by themselves; they also discuss fragments from Buchan and Lake Colongulac in Victoria, some from South Australia, and others from New South Wales. In regard to the Pejark Marsh fragments they say:

> We were at first, more especially perhaps as the aboriginal implement was of the nature of an anvil or pounding-stone, disposed to attribute to a human

agency the fragmentary condition of the bones forwarded by Mr. Merry; but further consideration and the securing of a larger collection have caused us to modify this opinion. We also thought that the place where the bones and implement were found was probably once a camp by the side of a lagoon or marsh, but our investigations on the spot led us seriously to doubt this original surmise. In the first place the bones in the patches disclosed were not accompanied by the concomitants of an aboriginal camp, and, more important still, many of the fragments obtained showed unmistakable evidence of the fact that some powerful predatory animal had been at work on them.

The cuts on the bones described by them differ in shape and length. In shape the shallow surface incisions vary from straight to slightly curved. They give the impression in many examples that the whole surface of the bone was scratched by a sharp-edged or pointed implement. There are, also, infrequent deeper cuts or gashes, V- or wedge-shaped in cross-section, some of which have been made at such an angle that they have removed a sliver of bone from its surface. Most of these they ascribe to the Dingo, the Thylacine, or *Sarcophilus*.

In the Pejark Marsh fragments, the cut most characteristic is a clean one, sloping slightly, in some specimens from 5 to 7mm. wide. In other specimens it is not single but multiple, directed to give the bone a pointed end, as, too, does a diagonal cut. The characteristic cut results in a shallow concavity similar to, according to them, that made by the carnassial of *Thylacoleo,* and it is their opinion that most of these cuts have been made by that marsupial. They describe, however, a bone with two cavities, on each side of the bone, one slightly in advance of the other. The curves of these cavities are much smaller than in the other specimens; one particularly seems as if it had been formed by several blows or applications of some instrument, by which small pieces were broken out, leaving a somewhat jagged edge. From the deepest part of the concavity towards the pointed end of the specimen, the thin outside layer of the bone has been removed and its margin is similarly defined by scallops. The shape of the pointed end, they state, is due to cuts.

They quote De Vis's statement as to the bone-cutting powers of *Thylacoleo* and instances where he shows bones exhibiting marks and impressions of its molars. After examining the Pejark bones they were convinced that they were cut by *Thylacoleo* which had evidently greater power in this respect than is attributed to it by De Vis.

Most of the *Diprotodon* bones obtained by S. R. Mitchell and myself from the Pejark Marsh bone bed exhibit the shallow surface incisions and a few gashes; only one—portion of the diastema—showed a clean, straight cut through bone about 5mm.

thick (Plate 2, Fig. 11). Another piece (Plate 2, Fig. 10) of a lower incisor, 120mm. long, with a longer diameter of 45mm. and a shorter one of 33mm. exhibits on its outer surface fine incisions and a gash or two. A lower incisor, broken across, shows at one end a fairly smooth, wind-polished cross-section, and at the other end, a very irregular one. The smooth section is due to a break made soon after the death of the Diptrotodon, for it shows numerous, shallow incisions made by the teeth of some small predatory animal when the incisor was green. The irregular cross-section at the other end is due to a break that occurred some time after death, and seemingly before the tooth was buried by deposition. The smaller diameter of the incisor is 1·25 in. and it was too massive for any animal to bite through. It is difficult to account for either of the breaks unless they were the work of man. That he was in the district at the time is shown by the occurrence of the Pejark Marsh Millstone in a bed below the bone bed.

Spencer and Walcott came to the conclusion in regard to the Buchan Bone that "in the absence of definite proof, that man was [not] at any time an occupant of the cave in which the Buchan Bone was found, and the cuts were made by *Thylacoleo*."

The bone fragments from Salt Creek, Normanville, South Australia, showed mostly straight, blunt gashes, a few the characteristic curve of the cuts of the Pejark Marsh bone fragments, but no example of the clean cuts right through the bones as at Pejark Marsh. They concluded that here too, all the cuts could have been made by *Thylacoleo*.

The cuts on the Myall Creek fragments from New South Wales are ascribed by De Vis to *Thylacoleo*; here again the clean cuts right through the bones are absent.

The Colongulac Bone was picked up on the shores of Lake Colongulac, about 10 miles E.N.E. of Pejark Marsh. The cuts (Plate 2, Fig. 9) are quite different in shape to any at Pejark Marsh. Spencer and Walcott state that they were made on the 4th metatarsal probably of the extinct *Palorchestes* and consist of two, deep, wedge-shaped notches extending a little more than half way across the bone. The greatest width of one notch is approximately 12mm. and that of the other about 10mm. Where the two notches are confluent on the margin of the bone, it has been penetrated to a depth of 6mm. The notch in the dorsal surface is, as nearly as can be measured, 10mm. in depth, compared with 6mm, in the case of the ventral one. Spencer and Walcott give the facts concerning the finding of the bone and accept its authenticity. They compare the gashes to one of the Myall Creek fragments which De Vis, if he examined it, attributed to *Thylacoleo* and state:

> There is admittedly, as regards size, a great difference between the Myall bone and the Colongulac bone, and moreover in the latter instance we have no corroborative evidence of the work of *Thylacoleo* in the presence of markings or cuts of any kind which might safely be attributed to him. At the same time it throws much doubt upon what might otherwise unhesitatingly be accepted as the handiwork of man, more especially when we know that that work is not of a nature practised by the natives of Australia in historical times.

It might be inferred from these comments that they were reluctant to attribute the gashes to other than man. In other words (1914 *circa*) they expressed the same indecision in connection with the Buninyong Bone:

> The acceptance of the authenticity of the work [on the Buninyong Bone] as that of prehistoric man including the cuts on the under side of the bone must discount very seriously the objections we have made to the possible human origin of the cuts on the Pejark and Colongulac bones on account of Australian man not being known to cut bones in such a manner, in which respect he must then have differed from his predecessors. Thus the deciphering of what is man's work and what is the work of beast becomes purely a question of deciding the work has been performed for a definite and useful purpose by an intelligent being or in the haphazard manner of a bone-eating animal.

There is little doubt that the Colongulac Bone came from a swamp deposit, in the author's opinion, one probably contemporaneous with the bone bed of Pejark Marsh which is above that from which the Millstone came; this being so, there is indirect evidence of man existing in the Lake Colongulac area when the Colongulac bone was fashioned. Its uniqueness and the fact that it may be man-made is sufficient justification for including it here with bones affording some evidence of antiquity. That the bone itself is ancient is shown by the fact that it is a metatarsal of the extinct *Palorchestes*.

Perhaps the most striking fact in this review of bone fragments shaped by man or cut by aninmals is that the clean cuts through the bones bearing so great a resemblance to the work of man are characteristic of Pejark Marsh and are not found on bones elsewhere, except perhaps, at Buchan. While there is no doubt that many of the incisions on the Pejark Marsh fragments have been made by animals, the fact that man lived in the district when they were made, suggests the possibility that some of them were made by him. With the illustrations of characteristic Victorian fragments (Plate 2, Fig. 2), others of bone implements from the Suffolk Bone Bed of Pliocene age illustrated by Moir (1932) are given to show the resemblance.

V. Palaeogeography of the Postglacial and Last Glacial Periods.

The Proto-Indics or Australoids by whatever routes they came to Australia had to pass over some deep channels and no eustatic lowering of sea-level in the last 50,000 years has been nearly sufficient to expose the floors of them. During the Postglacial, the last glacial stage (Wurm 3) and the antecedent interglacial, there has not been a landbridge connecting Australia with Asia or with the islands to the north except New Guinea. One existed at some earlier geological period long before the earliest evidence obtained by the writer of the presence of man in Australia. That the Proto-Indics in their migration southwards had recourse to sea-travel, was realized by Elliot Smith (1930) who pointed out that they had to cross Wallace's Line between Borneo and Celebes. In these notes on the palæogeography of the regions north of Australia, it will be seen that they had to pass over much wider extents of water. The distribution of land and sea during the Postglacial and at the close of the last glacial periods are discussed together with the climatic changes that are known to have occurred during those stages—changes that had a profound bearing on habitation and migration.

During the last glacial stage, Daly (1934) estimates a lowering of sea-level of about 294 feet. The northern strand line of Australia and the south-west strandline of New Guinea were then continuous; New Guinea was joined to Australia by a more or less extensive coastal plain (Fig. 10). This extended in places more than 150 miles north of the existing coastline of Australia, and on the south-western side of New Guinea some 350 miles, including what are now the Aru Islands; it extended as far east as Long. 145° which passes through the Gulf of Papua, east of Cape York. At its northern extremity, it was nearest Suli Mangoli, the easternmost of the Sula Islands of the Celebes Group, and in the west to Timor.

There are peoples in Sumatra, Borneo, and Celebes with a Proto-Indic background. These three islands were joinel during the 294 feet lowering of sea level except at the Strait of Macassar (Fig. 10) which, at its narrowest, was about 30 miles wide. To migrate to a region further south, the route, even if it were partly by land, was also necessarily by sea, requiring the use of some kind of sea-travel. There are certain probable routes leading to the point opposite and nearest to Australia, the shortest distance across the deep channels, routes that brought would-be migrants with their primitive means of transport within possible crossing-distance. These are the Celebes—New Guinea route, the Timor

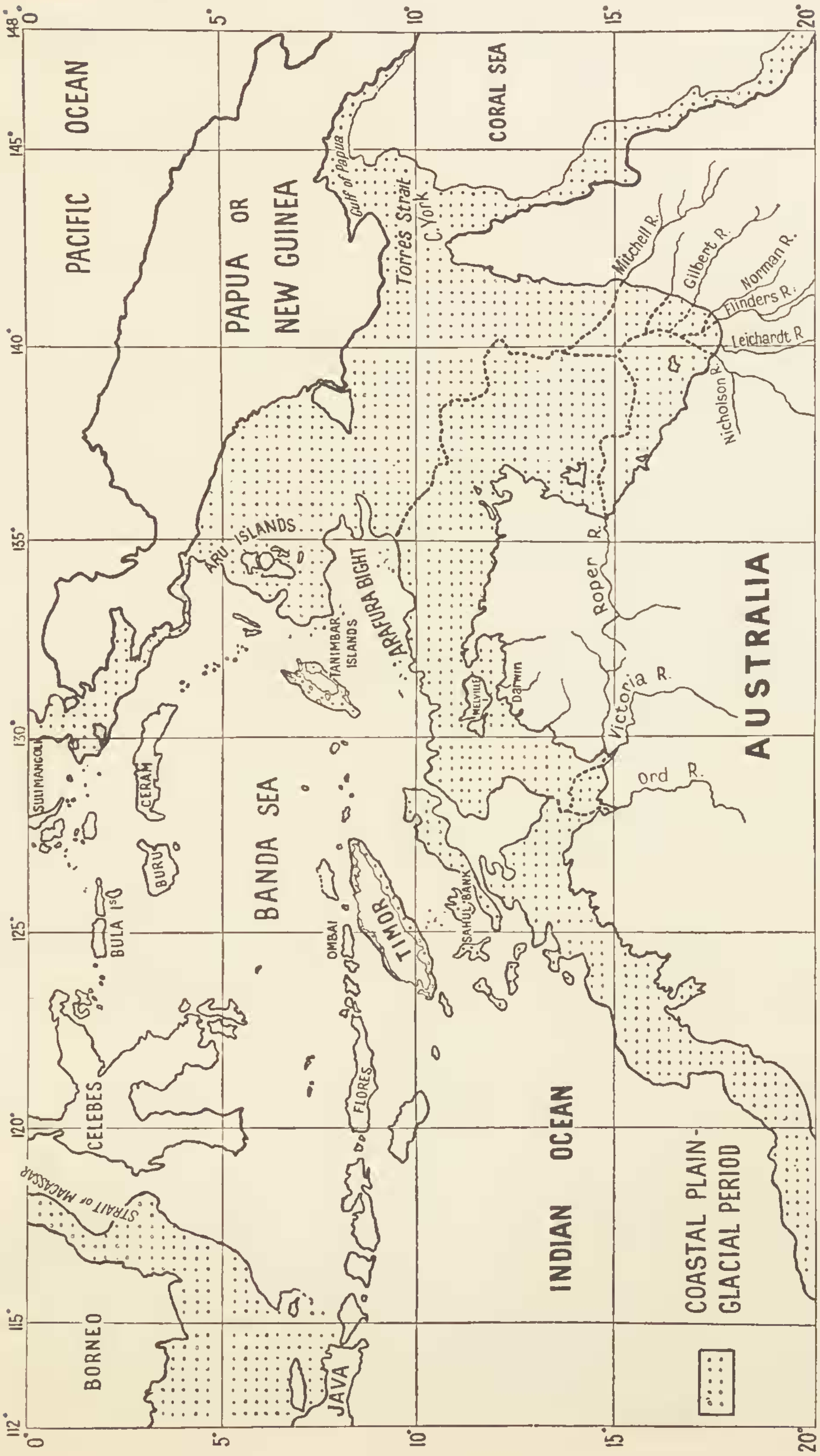

FIG. 10.
Coastal Plain of Glacial Period.

route, and the Timor-Tinamba route (Fig. 10). The least amount of sea-travel mileage necessary to cross the channels together with their depths is

Route	Least number of travel-miles			Depth in feet.
	Glacial Period	Rain-forest reached C. York	Mid-Postglacial	
Celebes-New Guinea	176	176	176	3,000
Timor	60	180	188	2,000
Timor-Tinamba	288	300	300	1,500

Soundings on the Admiralty Chart on the whole are too far apart for detailed bathymetrical contouring, but they plainly indicate three coastal plains in the profile (Fig. 12) of the continental shelf. The lowest shows up at 276 feet below existing sea-level, and, allowing for the recent 15-20 feet lowering of sea-level, is undoubtedly the surface of the coastal plain of the last glacial period. The high pinnacles in Fig. 11 are presumably due to

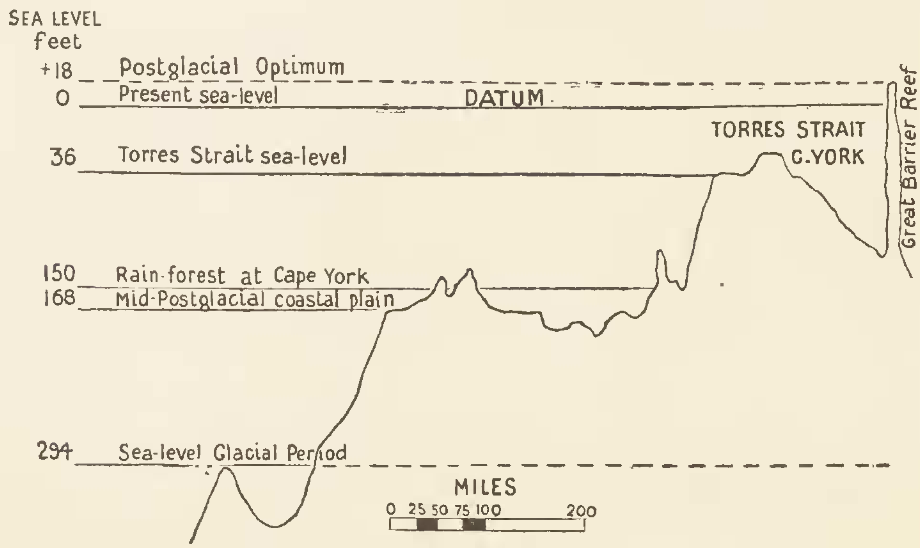

FIG. 11.

Section of sea-floor from outlet of Flinders River in Glacial Period through Torres Strait.

coral growths. That it was a land-surface formed by eustatic adjustment is suggested by the following indirect evidence. It will be noted (Fig. 10) that, during the last glacial period, the outlets of the Victoria and Ord Rivers of the western river system emptied into a landlocked bay across the opening of which lay an island. The floor of this bay was 174 feet below the mean level of the coastal plain during the glacial period, now about 264 feet below existing sea-level. Ascertained by soundings, this floor is mainly mud and sand but one sounding bottomed at a depth of 396 feet below existing sea-level, or 132 feet below the mean level of the glacial coastal plain, on "dead coral." The living range of coral is 120 feet, so that, taking this extreme range, sea-level when the coral was alive was 276 feet lower than it is now, an estimate, excluding adjustments for tectonic movement, that

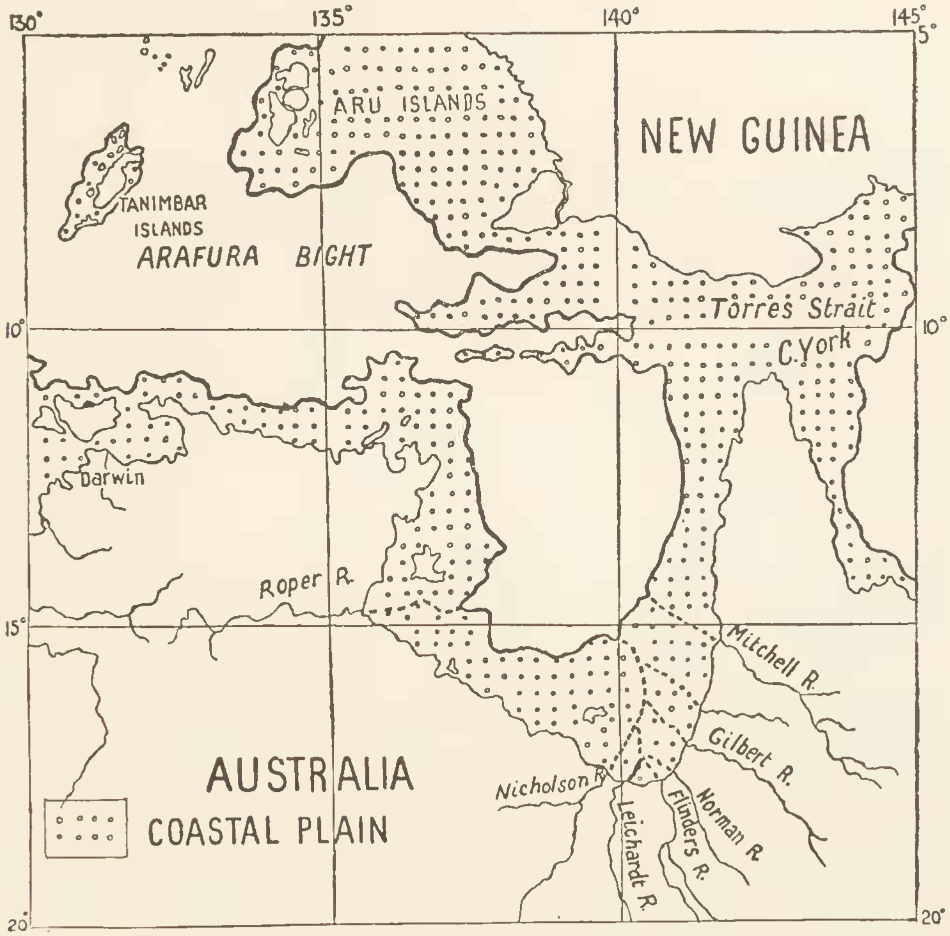

FIG. 12.
Mid-Postglacial Coastal Plain.

agrees fairly well with Daly's figure of 294 feet: if the coral lived on the bottom at a depth of 102 feet, there is complete agreement.

During the last glacial period, the Flinders, the trunk-stream of the mature eastern river-system of which the Roper, Nicholson, Leichhardt, Norman, Mitchell and other streams were part, crossed the coastal plain and emptied into the lowered sea-level of the Arafura Bight (Figs. 10 and 12). This system is a Pleistocene one and the trunk-stream had to adjust itself to the lowered sea-level of the last glacial stage; from its outlet into the Arafura Bight, there was probably a gorge some distance upstream cutting back into the mature erosion of the Pleistocene cycle, but the soundings are not close enough to show this. There was obviously in this region some tectonic movement, presumably subsidence, but its nature and extent are not known. There is evidence of another coastal plain at about 168 feet (Fig. 11) referred to here as the Mid-Postglacial coastal plain, and a more recent one in Torres Strait—the Torres coastal plain—at 54 feet (Fig. 11); but its surface is generally masked by coral-growths.

During the glacial period, the lower part of the basin of the Flinders River was, for the most part, in the arid belt but in the Mid-Postglacial period it was in the savannah (Fig. 13) with the tropical rain-forest on the north about to encroach on its eastern side. In the Mid-Postglacial period, the Flinders emptied into a landlocked bay, an evolutionary stage of the Gulf, about 150 miles north of its present outlet. This bay was about 340 miles long, subcircular at its southern extremity, but widening to a width of over 200 miles at its northern end. Its waters covered the basin of the drowned Flinders River of the glacial period, and the bay had a narrow entrance from the Arafura Bight through the drowned gorge. Immigrants, if they came by sea-travel, passed up the channel and crossed the bay to its southernmost extremity until they came to the outlet of the Flinders.

In the glacial period much of the Northern Territory was in the arid belt, as, too, was the Cape York Peninsula south of Point Duyfhen. The northern part of the Peninsula was in the savannah, also Tanimbar Islands, Aru Islands, and the coastal plain for 50 miles north of the present shoreline of Melville Island. The tropical rain-belt, extended north of a line approximately coincident with the W.N.W. political interior boundary of Papua. The line of maximum aridity—the middle of the arid belt—was a few miles south of the present outlet of the Flinders River into the Gulf of Carpentaria and trended W.N.W. to near the southern extremity of Cambridge Gulf in northern Western Australia. The arid belt itself reached about 350 miles further south to the steppe-region and east to the rainfall-reliability belt which reached as far north as the Atherton Plateau. The Flinders and some of its tributaries carried off the rainfall of the latter, and although the lower reaches of the trunk-stream flowed through the arid belt, it was, nevertheless, a river of some volume. When, however, it and its tributaries flowed over the Mid-Postglacial plain, it was not the full-flowing stream of the glacial period, for its headwaters were not in the rainfall-reliability belt which had moved southwards over 300 miles. It then drained mainly seasonal coastal rain.

The distribution of the climatic belts when the tropical rain-forest reached Australia is shown in Fig. 13.

VI. Probable Landing Places.

In the light of the palæogeography, the much discussed problem of the time of the arrival of the Proto-Indics or Australoids in Australia acquires a different setting to that presented by some anthropologists. It cannot be answered without taking into account the changing coastline and climate of the latest Quaternary periods, and the realization that some kind of sea-transport was necessary to cross deep channels.

Elliot Smith (1930) gives the ethnic relationship of the Australian:

> The aboriginal Australian belongs to a race that is sometimes called Pre-Dravidian, a term intended to emphasize the fact that certain jungle tribes of Southern India, the Kadir of the Anaimalai Hills, the Paniyan of Malabar, the Wynad and Nilgiris, the Irula and the Karumba of the Nilgiris, scattered among the Dravidian peoples, conform to the same physical type, and obviously belong to the same race. Before we attempt to discuss the antiquity of the population of Australia it is clearly important to remember this most westerly relic of the same people. The Vedda of Ceylon, the Sakai of the Malay Peninsula and East Sumatra, the Toala of Celebes, and possibly some other people of Borneo, provide evidence in corroboration of the fact of the migration of the Australian race.

The northern limit of the Australian Region being the northern extremity of New Guinea before Torres Strait was formed, the time of the arrival of the Proto-Indic in those parts must be regarded as his first appearance in any part of Australia. No attempt is made here to fix the time of this; it belongs to the distant past and the early migrations of man. The time of the first appearance of the Australoids in Australia in its present form is the immediate purpose. Having landed in what is now New Guinea, the routes taken by the migrants are conjectural, but they were presumably through the western half of that island; they could have moved partly by sea or along the highlands, or across the now submerged coastal plain. The only part of the coastal plain extant outside Australian waters is, seemingly, Aru Islands, now occupied by a Melanesian people of mixed strain. Keesing (1946) comments suggestively:

> Persons [of the Papuan type] . . . appear to show a considerable strain of the same racial materials as the nearby Australian Aborigine—the so-called Australoid features—combined with the dark Negroid elements uppermost in the region. It might be expected on the ground of geography, they are found

most frequently in the western and southern parts of New Guinea, nearest Australia. This strain also occurs here and there in the interior of the larger islands farther to the east, and in New Caledonia at the east end of the main chain.

Contrasting the accepted Melanesian type, he states that it is

concentrated more along the coasts of the larger islands, including the north and east of New Guinea, and in the small islands east of Fiji. Much the same physical characters are often found farther west in those parts of the Molucca-Timor regions and of east Flores not settled by the Malayan peoples.

In submitting that the Proto-Indics came as a jungle-people with the tropical rain-forest, the movements of the climatic belts and incidentally their movements are timed here from the peak for Wurm 3 in the curve for solar radiation (Zeuner, 1945) viz. 25,000 years ago. Zeuner gives (*op. cit.*) for comparison the estimates of others for this figure—De Geer 18,000 years, Heim 16,000 years, Steck 20,000 years and from 14,000 to 15,000 years, Penck and Brückner 24,000 years. Based on the 25,000 years of the solar radiation curve, the writer estimates that the tropical rain-forest reached Cape York, the northernmost point of Australia in its present configuration about 15,000 years ago, but it must be proportionately less if we accept the other estimates, viz.:

De Geer	Heim	Steck	Penck and Bruckner
11,000	10,000	12,000 and 8,500 to 9,500	14,000

Assuming a progressive Postglacial rise of sea-level since Wurm 3, the coastal plain of the glacial period was submerged about 24,000 years ago, the Mid-Postglacial plain about 16,000 years ago and the 54 feet coastal plain to form Torres Strait about 8,000 years ago. These estimates are necessarily approximate for it is known that there were, in glaciated regions, fluctuations in the recession of the ice-sheet during the general retreat of the ice that are possibly reflected in the movements of sea-level.

That portion of New Guinea nearest Suli Mangoli has always been in the tropical rain-forest, and immigrants from Celebes to New Guinea passed from one part of the forest to another. In the west, if the 60 mile channel separating Timor from Australia was crossed by a hypothetical people during the glacial period, the crossing was from one arid region to another. Conditions were more inviting when the rain-forest reached contiguous points on Timor and the mainland about 11,000 years ago, but the strait had then widened to about 150 miles.

A good deal of interest attaches to the means of transport as the most primitive craft known are recorded from north-west Australia. Pitt-Rivers (1906) traces back the development of sea-going craft to the pointing of the ends of a solid tree-trunk—the first stage of the dug-out canoe. He cites Gregory who relates that when his ship was off the north-west coast of Australia in 1861, it was visited by two natives who came on logs about 7 feet long and a foot thick shaped like canoes, not hollowed out, but very buoyant, which they propelled with their hands only, their legs resting on a little rail made of small sticks driven in on each side. Pitt-Rivers corroborates Gregory's statement with a description of such craft from another source. He also mentions the dug-outs used by the aborigines on the shore of south-eastern Australia near Cape Howe seen by Captain Cook in 1770. The dug-out reached Britain before the Neolithic industry. Childe (1929) mentions that deep-sea ships sailed between the Indus and the Euphrates over 6,000 years ago. No certain representations of these are known, but some depicted on a Babylonian vase suggest that they evolved from river craft.

VII. Critical Millennia.

Elkin (1938) commenting on the arrival and migrations of the aborigines states:

> They landed in northern Australia, probably on Cape York Peninsula and perhaps also at different times on other parts of the coast. From there they gradually spread across the continent, though we cannot speak with certainty about the routes followed. They probably spread around the north and down the east and west coasts; down the Queensland rivers on to the Diamantina and Cooper and so into South Australia; from the Queensland coast on to the headwaters of the Barwon and along the Darling River system and on to the Murray right to its mouth; and gradually across the deserts from north to south until the Bight was reached.

These are, for the most part, the routes suggested by the vicissitudes of the Postglacial climate.

Although the tropical rain-forest reached the Cape York Peninsula (Fig. 13) approximately 15,000 years ago, its advancing edge was probably not sharply defined and it was preceded by forest country merging into savannah; this the jungle-people penetrated. "Desert and dense forest are the extremes," says Marett, "between them—anywhere in fact between open steppe and park-land, lies the happy mean, not only for the hunters but likewise for the food-raising peoples." But the Proto-Indics were essentially a jungle-people and in no sense a food-raising people. How far habitable conditions for such existed on the so-called savannah south of the fringe of the tropical rain-forest is problematical. If we could determine it with certainty, we might say with more precision when they appeared on the Australian mainland. The northern half of the savannah to which these habitable

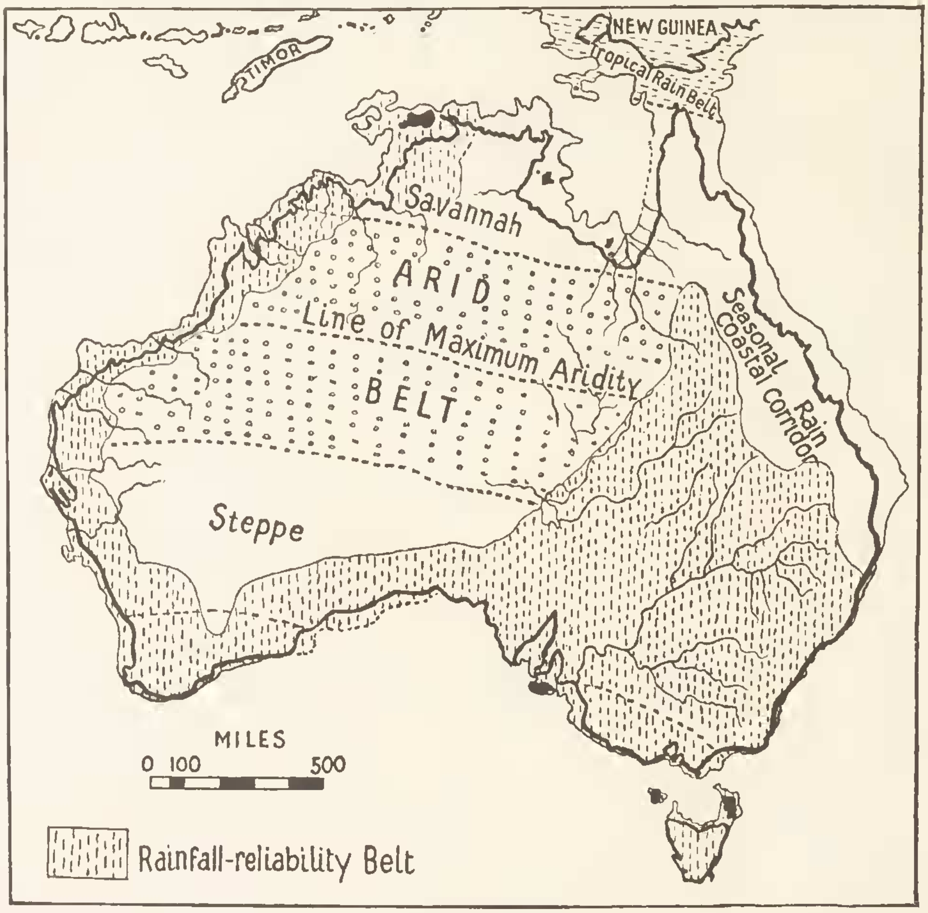

FIG. 13.
Climatic Belts and Rain-reliability Belt when the Tropical rain-forest reached Cape York.

conditions were seemingly confined, reached the Cape York Peninsula about 21,000 years ago. An estimate based on these considerations is that the Australoids came between 15,000 and 18,000 years ago, at a time when the savannah was habitable and before it showed signs of the approaching aridity. That the Australoid could acclimatize himself to arid conditions is evident from his subsequent history; that he did not at first choose an arid environment is obvious.

When Torres Strait was formed, he was completely cut off from communication by land with other races. It is probable that during the 7,000 years between his first appearance and his isolation, there were at least three waves of migrants.

Those who used the western route either came by the littoral as migrants from the east or as immigrants by some kind of craft. Although the shortest distance from Timor to the mainland was the most likely route taken, other routes were possible. As contiguous sides of the strait separating Timor from the mainland were both in the tropical rain-belt for the first time in the Postglacial period 11,000 years ago, it seems likely that immigration by this route started then. There are no records of Proto-Indics east of Java in the Sumatra-Timor chain of islands; this is peopled by Malays and Melanesians. It may be found that the Proto-Indics were there 11,000 years ago, but their suspected absence makes the spread of the tropical rain-forest to Timor and the mainland less significant.

The following tabulation gives the years previous to the present time when geographical, climatic, and environmental conditions existed.

Years.	Geographical, climatic and environmental conditions.
2,000	End of period of extreme aridity.
4,000	Postglacial Optimum. Arid belt reaches southernmost limit.
6,000	Beginning of period of extreme aridity in southern Australia.
8,000	End of pluvial period in southern Australia. Torres Strait formed; Australia isolated from New Guinea.
11,000	Rain-forest reached both sides of Timor Strait.
15,000	Tropical rain-forest reached Cape York Peninsula.
16,000	Mid-Postglacial coastal plain.
18,000	Probable first appearance of Australoids in Australia.
24,000	Beginning of submergence of the glacial coastal plain.

As stated (*supra* p. 70), these figures are based on the radiation curve and a maximum estimate for Wurm 3, but if Steck's minimum estimate for this be taken at 9,000 years, the appearance of the Australoids in Australia in its present form was less than 6,500 years ago, and the other figures correspondingly less.

VIII. Migration Routes in Australia

As Cape York Peninsula as part of the old land-bridge that joined New Guinea to Australia was the first and main place of entry for the Proto-Indics, the degree of habitability in the past of the tracts leading from it suggests the favoured routes for migration on the mainland. The availability of food and water was the assurance that intending migrants sought, and this was regulated by the movements of the climatic belts and with them the rainfall-reliability belt. As pointed out, the latter moved furthermost north in the glacial period and widened to its maximum, while during the greater part of the Postglacial, it slowly moved southwards and contracted to its minimum at the Postglacial Optimum. The fertility of eastern Australia has been influenced by the fact that the Great Dividing Range skirts its eastern coastline and is responsible for the coastal corridor and the orographic rainfall belt; on the other hand, the fertility of the coastal belt of western Australia has been complicated by conditions not found in the east.

In connection with migration, climatic conditions are discussed 25,000 years ago during the glacial period; 15,000 years ago or thereabouts when the tropical rain-forest advanced into the Cape York Peninsula; 8,000 years ago when Torres Strait separated New Guinea from the mainland, and 4,000 years ago at the Postglacial Optimum. The fertile tracts at these times are best considered by grouping the rivers into basins in respect to the sources, intake, and outlets of the drainage channels of the contracting rainfall-reliability belt and the advance southwards of the arid belt. This grouping is tabulated.

Basins	Rivers	Source	Outlet	Rainfall
I Carpentaria (western part)	Roper, McArthur, Gregory, Leichhardt, Cloncurry.	Selwyn Highlands	Gulf of Carpentaria.	Tropical
II Carpentaria (eastern part)	Mitchell, Gilbert, Flinders.	Great Dividing Range	Gulf of Carpentaria.	Tropical orographic, monsoonal.
III Diamantina	Diamantina, Georgina, Hay.	Selwyn Highlands, Macdonnell Ranges	Lake Eyre	Tropical
IV Cooper	Cooper, Thomson, Barcoo.	Great Dividing Range	Lake Eyre	Tropical orographic
V Darling	Darling, Barwon, Paroo, Warrego, Condamine, Macintyre, Gwydir, Namoi, Castlereagh, Macquarie, Bogan.	Great Dividing Range	Murray River	Orographic
VI Murray	Murray, Lachlan, Murrumbidgee, Goulburn.	Great Dividing Range	Southern Ocean	Orographic

In the glacial period, the rainfall-reliability belt extended on the west side of the Main Coast Range as far north as the Atherton Plateau, and west from the Great Dividing Range beyond Lake Eyre covering most of the Diamantina Basin (III) and the Cooper Basin (IV); west of it to the western coastal belt. Central Australia and a large part of Western Australia was in the arid belt and steppe region. The whole of south-eastern Australia, south of the latitude of Grafton, was covered by it including the drainage systems of the Darling (V) and the Murray (VI).

About 15,000 years ago, when the tropical rain-forest reached Cape York, the rainfall-reliability belt had somewhat contracted. It then extended as far north as Georgetown in Queensland, and as far west as Lake Eyre, covering the eastern half of the Diamantina Basin (III) and the whole of the Cooper Basin (IV); the rest of its cover was much the same as in the glacial period.

Approximately 8,000 years ago, when Torres Strait was formed, the climate was as it is now. The line of maximum aridity (Fig. 1) passed from a little south of N.W. Cape in Western Australia, about 50 miles north of Lake Eyre, to near Walgett in New South Wales. Theoretically, the coincident line of the northern front of the arid belt passed through Boulia in Queensland and its southern front was covered by the westward extension of the belt of rainfall-reliability. North of the arid belt was savannah and south of it steppe. The rivers of the Diamantina Basin (III) had their sources in the savannah and outlets into Lake Eyre in the arid belt; the Cooper Basin (IV) was wholly in the arid belt.

At the Postglacial Optimum, 4,000 years ago, the northern peak of the rainfall-reliability belt had receded south to about the latitude of Maryborough in Queensland; the line of maximum aridity then passed approximately through Marree south of Lake Eyre, the northern front of the arid belt through Alice Springs, and its southern front was covered by the rainfall-reliability belt. The headwaters of the Darling—the upper reaches of the Condamine and some of its southern tributaries, were during the Postglacial Optimum within the rainfall-reliability belt. The rest of its valley (V), almost to its confluence with the Murray, was in the arid belt which began to encroach on it about 5,000 years ago. The take-off or orographic rainfall in the Darling Basin has been, during this period, small; it has been estimated that now, 4,000 years after the Postglacial Optimum, due mainly to evaporation, less than 2 per cent of the rain falling in the upper Darling valley passes the town of Bourke on its middle reaches. The headwaters of the rivers of the Diamantina and Cooper basins were in the savannah, but their middle and lower reaches in the arid belt. It has been already pointed out that since the early part of the Postglacial, the rivers of the Diamantina Basin (III) have not been channels for orographic rainfall, and their drainage has been, for the most part, the scanty tropical rainfall of the sub-tropics.

From the climatic standpoint, the problem of migration along the west coast of Australia is a difficult one. In Fig. 13 delimiting the climatic belts when the tropical rain-forest reached Cape York, a belt of coastal rainfall is shown extending up the coast of Western Australia as far north as Cambridge Gulf. This is based on the assumptions that the average path of the lows was considerably north then to where it is now, (Fig. 3) orographical rainfall was intercepted by the Great Plateau of Western Australia of an average height of from 1,000 to 1,500 feet, and this rainfall belt extended north across the western end of the arid belt. Several considerations arise, however, to confuse this simple solution; these include the converse effect to that of the east coast of the prevailing winds in the north-west blowing from the interior of the continent instead of from the ocean, the prevalence of deserts on the west coasts of the continents, and the presence offshore of the branch of the Southern Ocean Current. That there has been a wetter climate in this region is established by ample evidence. Quite recently, Teichert (1946) added to this by noting the presence on Houtman's Abrolhos, 50 miles west of Geraldton, of a rat, a variety of a species now only found on the south coast and southern islands of Western Australia, also a wallaby, a variety of one whose distribution does not now extend much further north than Perth. As representatives of the original stock are now restricted to latitudes considerably south of the Abrolhos Islands, he infers that there has been emergence and a change in climate—a rise in the temperature of about 5°F.

It is evident from this review of former climatic conditions, Australia north of the Murray and west of the Great Dividing Range, or precisely west of the rainfall-reliability belt, has passed through periods of fertility and aridity. Regions that were formerly well-watered and fertile have, with the march of the climatic belts, become deserts, and desert areas have become fertile. The river valleys have been singled out because food and water available along their banks during periods of fertility made them attractive to migrants. This may be inferred from a statement by Elkin (1938):

> The area of the tribal territory varies, for the most part, with the nature of the country, more especially according to its fertility and food supply. Thus, on the north coast of New South Wales a narrow strip of country, roughly 300 miles long by sixty to ninety miles in width but well watered by rivers and a good rainfall, there were several tribes on each river, numbering altogether about twelve with several sub-tribes, whereas in the drier interior of the State the Wiraduri alone occupied more territory than all these tribes put together. Likewise, along the Queensland coast, the country along the Daly, Fitzmaurice and Victoria rivers of the Northern Territory, and in the upper Murray region in Victoria and New South Wales, the tribal areas were comparatively small, whereas the Aranda of Central Australia occupied a large tract of country stretching from about Hermannsburg eastwards well beyond Alice Springs and

south-east right down the whole course of the River Finke for a distance of 400 miles.

And again, in discussing the improbability of the aborigines being only long enough in Australia to increase to their number when the white man came, he states:

. . . . we know that in many tribes even in good country, a balance between numbers and food resources is maintained by infanticide and sometimes by abortion. In times of severe drought in the drier parts of the continent, infanticide is apt to be practised temporarily in the interests of the adults without any thought of the future of the group.

These quotations indicate how dependent the aborigines were on the fertility of a region and its implied food resources but that, even with fertility in their Australian environment, a balance between numbers and the food available had to be maintained. For a former tropical rain-forest people to favour the arid belt for habitation is unthinkable; their first contact with it would be a deterrent. As Marett (1938) says:

More especially inhospitable is the arid type of desert, more so even than the frozen type of tundra; lack of rain being the physical scourge that man has to fear most. Nay, as a cause of migration on a grand scale desiccation is perhaps more effective than any cultural influence . . .

Taylor's estimate (1927) of the aridity in northern Australia during the Pleistocene Ice Ages applies also to the arid belts during the Postglacial period:

We may picture much more repellent conditions in the north during the Pleistocene Ice Ages than obtain today. These may well have prevented any higher race from following the aborigines into Australia.

From the standpoint of subsistence, the fertile tracts with their relative sufficiency of food and water, were the first to be occupied. These were, 15,000 years ago when the tropical rain-forest reached Australia, the coastal corridor and the rainfall-reliability belt which covered the south-east, a narrow avenue at the head of the Great Australian Bight, south-west Australia, and the western coastal corridor. It also extended at this time as far west as Lake Eyre and a triangle (Fig. 13) converging from the head of the Bight on the west, and Grafton on the east, subtended at the north by Georgetown in Queensland.

This triangle embraced part of the Lake Eyre basin, western New South Wales, and a large part of inland Queensland. From the aspect of climate and fertility, it may be assumed that it formerly enclosed an area carrying a relatively large population of aborigines in small tribal areas, but now, as it is wholly within the arid belt, it is sparsely peopled and the tribal areas are large such as Elkin mentions in referring to the Aranda. Some of its former inhabitants have migrated to more hospitable regions but the remnant has deteriorated with the increasing aridity.

On the other hand, that part of northern Australia now within the tropical rain-belt was formerly in the arid belt. It is estimated that the arid belt left the Carpentaria Basin (I and II) about 9,000 years ago and the lower reaches of the Daly, Fitzmaurice, and Victoria Rivers have been in the tropical rain-belt for 11,000 years. Doubtless, on the lower parts of these rivers, the population has grown with their increasing fertility, brought about by the march of the climatic belts.

On the principle that the fertile tracts were the first occupied this deterioration and amelioration of climate suggests that those which have relapsed from fertility into aridity may well contain remnants of the first-comers to the mainland, while those that have passed from aridity into a condition of fertility, are peopled by later migrants.

The aborigines did not wage war for territorial aggrandizement (Elkin, 1938); their habitat was forced on them by the urge for food and water, not by an aggressor.

IX. Digest of Conclusions.

The main submission in these notes is that the Australoids were a jungle-people who entered Australia before New Guinea was separated from it, in their natural environment—the tropical rain-forest, or a short time before, when forest began to cover what is now the Cape York Peninsula. In the last 150,000 years there has not been a land-bridge connecting Australia with Asia and the Proto-Indics had to cross deep channels whether they came by the Celebes-New Guinea route or the Timor route. The time when these geographical, climatic and environmental conditions existed was between 15,000 and 21,000 years ago, in the early Recent or Postglacial period; the time of their entry is estimated at about 18,000 years ago; this figure is based on the maximum assumption of 25,000 years for the last glacial stage, but if one accepts Steck's minimum estimate for this, it was as recent as 6,500 years ago. It is highly probable that they entered by the Mid-Postglacial coastal plain (p. 67). It is thought some of the aborigines of the north-west and west migrated from eastern Australia, but others may have entered by the Timor route (p. *ante*) in the last 11,000 years.

In the east, migration southwards was along the coastal corridor and the orographic rainfall-belt to fertile south-eastern Australia. With the march of the climatic belts and the contraction of the rainfall-reliability belt, regions that were formerly well-watered and fertile have become desert, and desert areas have become fertile. This deterioration and amelioration in the climate suggests that regions that have relapsed from fertility into aridity may well contain remnants of the first-comers to the mainland, and those that have passed from aridity into a condition of fertility may be peopled by later migrations. The coastal corridor, orographic rainfall-belt, and south-east Australia have always been more or less fertile, and in these areas we should find the earlier migrants.

Evidence of antiquity from the south-east—Victoria and South Australia—points to a Postglacial age for the appearance of the aborigine. The following are the estimated ages of some artefacts, comprising Neolithic, Mesolithic, and Palaeolithic types, found in the south-east: Altona, 3,000 years; Colongulac Bone, 3,000 years; Pejark Marsh Millstone, 3,000 years; Bushfield Axe, 6,000 years. The age of the Buninyong Bone and Maryborough Axe, the Myrniong implements, and the earliest industry of Tartanga cannot be given in years but they are believed to belong to the lower half of the Postglacial or Recent.

If the first wave of migrants came just before the tropical rainforest, say 18,000 years ago, they passed over a land-bridge that 8,000 years ago became the floor of Torres Strait. During the intervening 10,000 years, other waves of migrants, no doubt, entered Australia by this land-route, but the Australoids have been cut off from contact with other ethnic types, except by sea, since Torres Strait was formed.

It has been stated that they were originally a jungle-people. This is inferred from communities elsewhere, the Proto-Indics of southern India—the Kadir, the Irulas, the Vedans (identical with the Veddahs) and others who live in the forest on its produce and the wild animal-life in it. The Veddahs of Ceylon and the communities in Sumatra, Borneo, Celebes, the Malay Peninsula, and Siam differed little in their pristine state from the southern Indian Proto-Indics; they, too, were essentially jungle-peoples. They came to Australia as such and, doubtless, remained so until they were compelled to migrate to the savannah and the steppe; when these relapsed into aridity with the march of the climatic belts, those who could not pass on remained to become a "broken people, battered vessels seeking harbour where they could."

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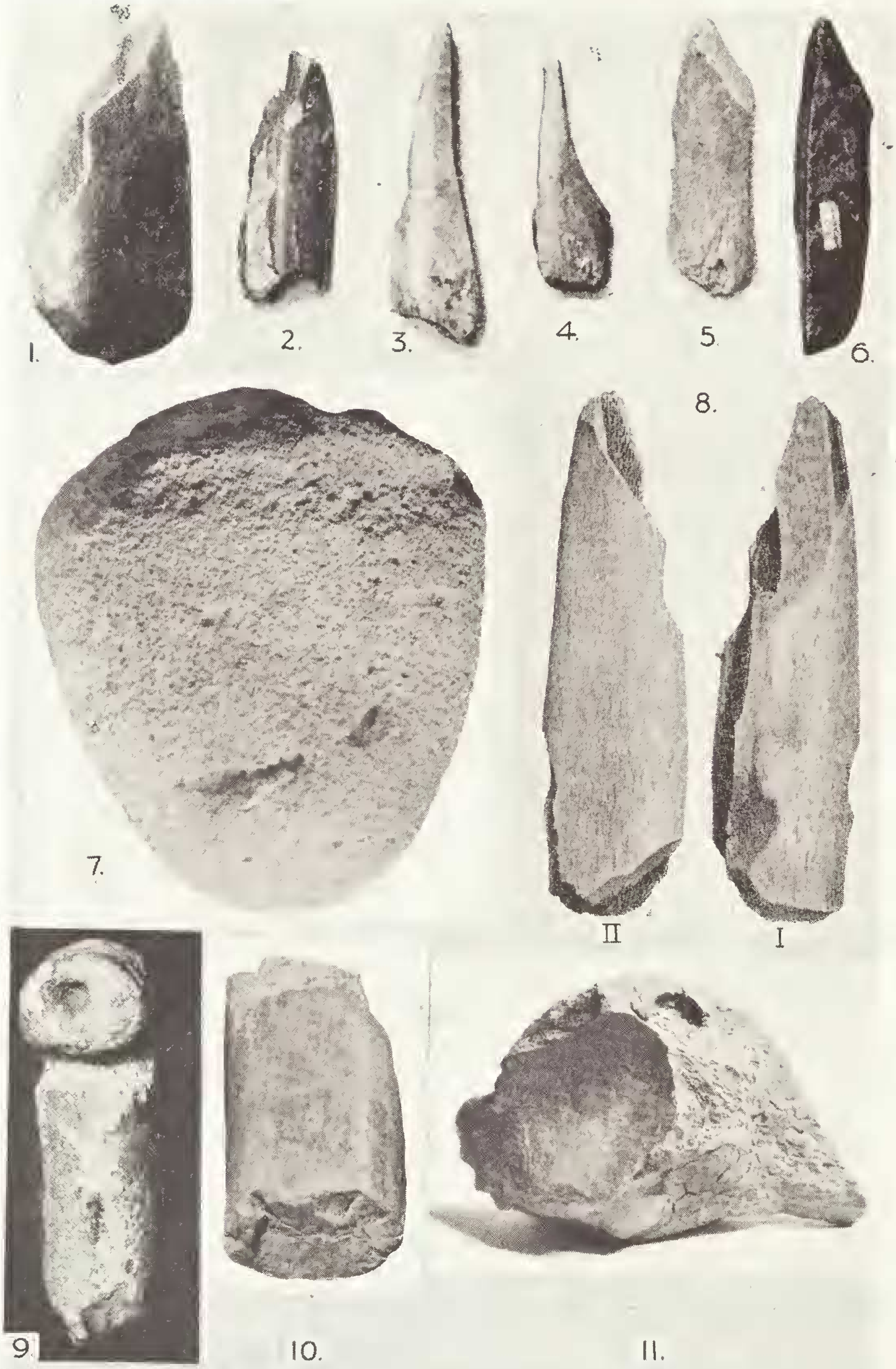
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EXPLANATION OF PLATE.

Plate 2.

Fig. 1. Suffolk, England. Pliocene bone implement from beneath the Red Crag, illustrated by Moir (1932).

Fig. 2. Pejark Marsh, Victoria. Fragment of a limb bone, with one of its corners sliced off by an oblique curved cut. About natural size. From Spencer and Walcott (1911).

Fig. 3. Pejark Marsh. Concave and convex fractures, producing a pointed fragment. According to Spencer and Walcott (1911) the convex fracture is due to the entry of pointed teeth penetrating the bone, both from above and below; the concave fracture may have originated from an incision in the broad end of the bone. Nearly natural size. From Spencer and Walcott (1911).

Fig. 4. Pejark Marsh. Piece of limb-bone with curved cuts attributed by Spencer and Walcott (1911) to *Thylacoleo*. About natural size.

Fig. 5. Pejark Marsh. Oblique cuts believed by Spencer and Walcott (1911) to be similar to those cut with the upper pre-molar of Thylacoleo. About natural size.

Fig. 6. Suffolk, England. Pliocene bone implement from beneath the Red Crag, illustrated by Moir (1932).

Fig. 7. Bushfield Axe, from Bushfield near Warrnambool, Victoria. Two-thirds natural size.

Fig. 8. Buninyong Bone from Buninyong, Victoria. From De Vis (1900). About two-thirds natural size.

Fig. 9. Colongulac Bone from Colongulac, Victoria. Side view, showing the confluence of the two notches. From Spencer and Walcott (1911). About natural size.

Fig. 10. Pejark Marsh. Lower incisor of *Diprotodon* obtained in bone bed below tuff. About two-thirds natural size.

Fig. 11. Pejark Marsh. Portion of the diastema of *Diptrodon* showing a straight cut; the concavity is the socket of the lower incisor. About natural size.